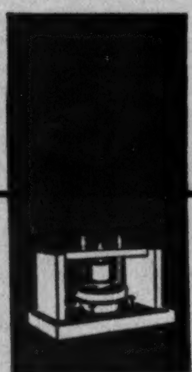
BELL LABORATORIES

RECORD



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VOLUME XXX NUMBER 11 NOVEMBER 1952

Spatial Harmonic Traveling-Wave Amplifier

S. MILLMAN
Director of Physical Research

The success of the traveling-wave tube as a wide-band amplifier for microwave radio frequencies has led to efforts to extend the traveling wave principle to still higher frequencies. The principal difficulty in doing this is that at very high frequencies the circuit elements get to be vanishingly small. At 4,000 mc, corresponding to a wavelength of 7.5 cm, a traveling-wave tube such as that already described in the RECORD* is very satisfactory. An experimental tube† of the same general type has more recently been built for operating at 48,000 mc—a wavelength of six and one-quarter millimeters. The very small size of such a tube introduces a number of difficulties, however. One of the most important is that the helix, which all such tubes have hitherto employed, becomes very delicate. To avoid this difficulty a modified type of a traveling-wave tube for operating at 50,000 mc has recently been built in which the helix has been completely eliminated, and thus a much more rugged structure has been achieved.

To obtain amplification in a traveling-wave amplifier, a stream of electrons and the electromagnetic wave to be amplified must travel together down the tube at approximately the same speeds. Since the electromagnetic wave travels at a speed approaching that of light, and since electrons cannot be given such speeds except under the influence of tremendously high voltages, some method must be devised for slowing down the wave to speeds that electrons will attain under the influence of practicable voltages. In almost all the earlier traveling-wave tubes this slowing down was achieved by constraining the wave to travel along a closely wound helix. Although its velocity down the wire is very high, its velocity axially along the tube is reduced by the

* RECORD, *December*, 1946, *page* 439.

† RECORD, *January*, 1951, *page* 14.

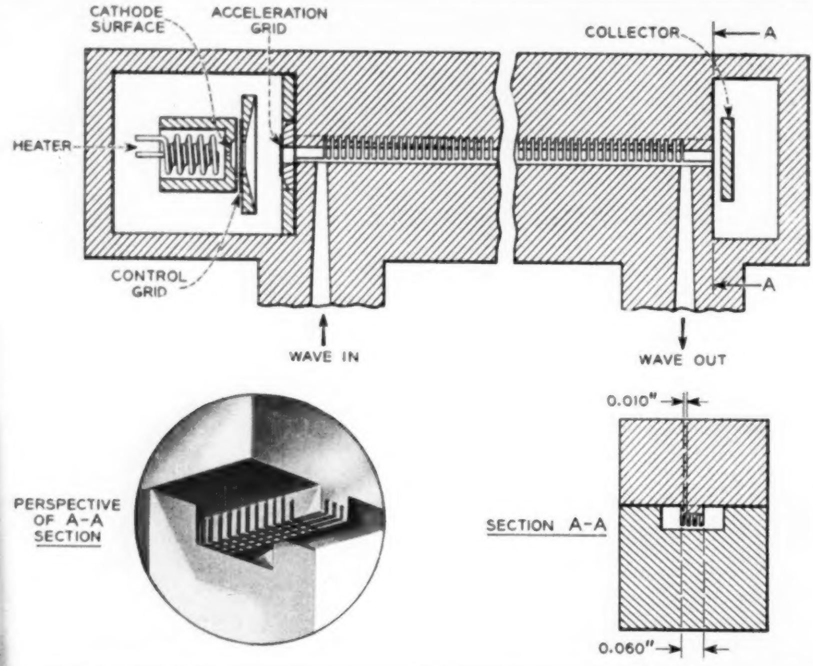


Fig. 1—Cross section of the spatial harmonic traveling wave amplifier.

ratio of distance along the wire to distance down the tube.

In the new 50,000-mc tube, the electromagnetic wave is not slowed down enough to make its speed approximate that of the electrons. Instead, the equivalent effect is obtained by having the electron stream react with what has been called a spatial harmonic of the original wave. In this way a moderate voltage may be applied to accelerate the electrons without the need of a helix for slowing down the wave to approximately the same speed.

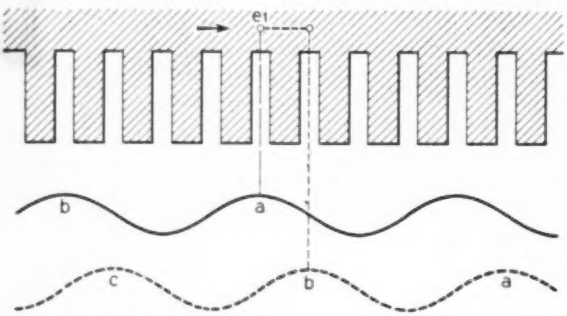


Fig. 2—Relationships between electromagnetic wave and the slots in the amplifier.

A cross section of this new tube is shown in Figure 1. The electrons emitted from the cathode at the left pass down the center of a channel in a copper block to a collector at the right. They are made to travel with a minimum of transverse motion by a magnetic field, as with the earlier types of traveling-wave amplifiers. The electromagnetic wave enters and leaves the tube through wave guides at the beginning and end of the channel as indicated. Down the center of the channel is a metal block with three axial slots as indicated in section A-A of Figure 1, and it is down these slots and close to each side of the projecting block that the main stream of electrons travel. Transverse resonator slots, 100 of them in all, cut through the central block at right angles to the axial slots, as indicated at the lower left of Figure 1, constitute the radio frequency circuit guiding the electromagnetic wave.

Amplification is brought about by the reaction of the electrons and the axial component of the electric field of the traveling wave. Near the surface of a conductor, however, the axial component of the electric field disappears, and thus it is only

while the electrons and the electromagnetic wave are crossing the transverse slots that the principal reaction between them occurs. If the electrons were traveling at the same speed as the wave, and at some particular slot the wave were at such a phase that the electrons exerted an amplifying effect on it, then at the next slot the phase relations would be the same and amplification would occur there also. This would continue for the rest of the way along the path of the slots.

Suppose again that at some slot near the beginning of the path the wave at a transverse slot is at a phase such as to permit amplification by a group of electrons passing that slot. Suppose now, however, that the electron stream is moving so much slower than the wave that by the time the same group of electrons reaches the next transverse slot, the wave has traveled one whole wavelength farther than in the above example. The wave and electrons at this

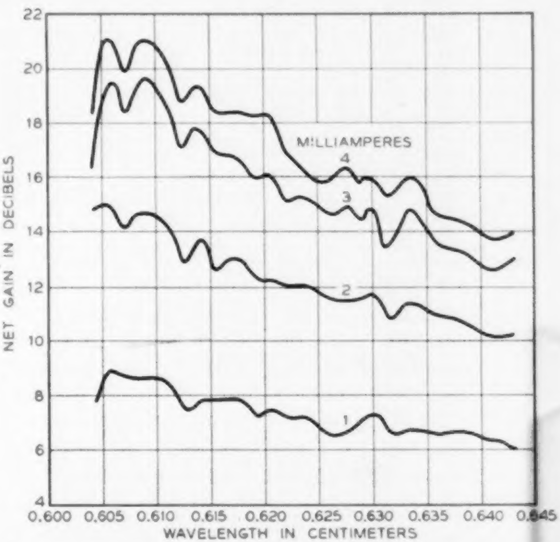


Fig. 3–Relationship between power gain and wavelength of the spatial harmonic amplifier.

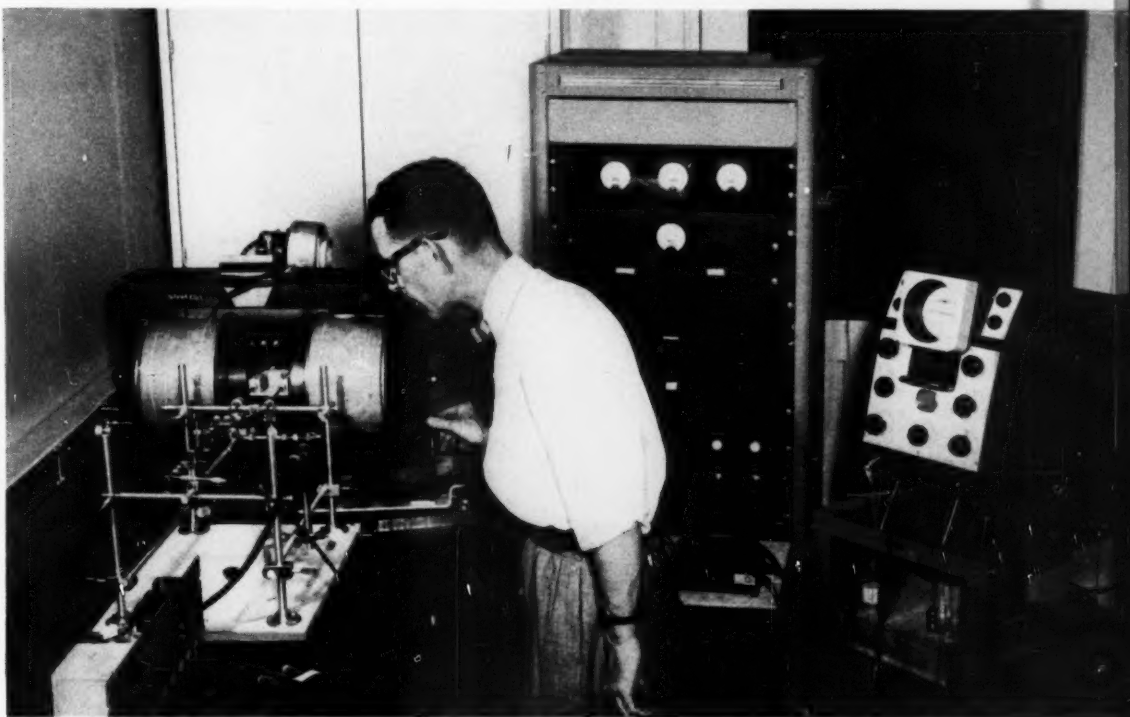


Fig. 4–R. F. Heck adjusts the electromagnetic field with respect to the spatial harmonic amplifier, in order to make the axial slots in the tube accurately parallel to the direction of magnetic field. This provides for a maximum of electron transmission.

second slot will then also be in the proper phase for amplification, but this time the electrons react on the next following cycle of the wave.

This is indicated graphically in Figure 2. Here a group of electrons marked e_1 is interacting at a transverse slot with a particular phase of cycle "a" of the wave. When this group of electrons has reached the next slot, the wave has advanced sufficiently to bring the corresponding phase of cycle "b" to the next slot, and again amplification takes place. Similarly, at each successive slot the electrons will react favorably with the wave, but with a later part of it. The same action is taking place with all the electrons, and thus the total amplifying effect is essentially the same as though the electrons were traveling at the same speed as the wave. Actually, however, they are traveling slower in the ratio of $d/(d + \lambda)$, where d is is the distance between centers of adjacent slots and λ is the wavelength of the traveling wave in this particular wave guide structure.

In this way it is possible to have the electrons travel considerably slower than the wave in free space without the use of a helix or the need of having the transverse resonator slots too close together. This is accomplished with an electron speed corresponding to only about 1,200 volts. Although the structure is small, the entire length of the path by 100 transverse slots being only about two inches for the 50,000-mc tube, it is very rugged and should thus prove much more satisfactory as a practicable amplifier.

The dependence of power gain on wavelength is shown in Figure 3 for several beam currents. The small irregularities are believed to be due to internal reflections that arise from non-uniformity in construction of the resonator slots. These are only 6½ ten thousandths of an inch wide for the tube shown, and their width, their depth, as well as their center to center spacing must be held to about 1 ten thousandths of an inch to secure the proper gain as well as the relatively smooth curves shown. The band width of the amplifier is about 3 per cent, which is 1,500 mc for a six millimeter amplifier. The estimated power is about twenty-five milliwatts. The observed gain of over 20 db is quite encouraging for frequencies around 50,000 mc per second.

THE AUTHOR: Sidney Millman, named Director of Physical Research last January, was graduated from City College of New York with a B.S. degree in Physics in 1931. He received M.A. and Ph.D. degrees from Columbia University in 1932 and 1935, respectively. He continued research at Columbia for the next four years, holding the Tyndall Fellowship in 1935-36 and the Barnard Fellowship the following year. His special interest was nuclear spins and magnetic moments using molecular beam methods. In 1939 he taught at City College of New York and two years later at Queens College in New York. From 1942 to 1945 he was associated with the Columbia Radiation Laboratory, under the auspices of the O.S.R.D., where he carried on a program of research and development in microwave magnetrons. Dr. Millman joined the Laboratories in 1945 and was first engaged in electron-dynamics research. Prior to his recent appointment, he had been studying traveling wave amplifiers for millimeter waves.

Craft Milling

An experimental traveling wave amplifier for extremely high frequency was recently constructed in Bell Telephone Laboratories.* Inside it is a remarkable example of fine mechanical craftsmanship. A rectangular copper block ¼" x ⅜" x 2¼" which will carry the radio frequency waves, is cross slotted on a 1/16" raised section in the center of the top face (Figure 1 above). Some variation in the shape of the longitudinal slots is tolerable so long as the center-line is straight, but the distance between centers of the 100 transverse resonator slots, the smoothness of their inner faces, and their width and depth are highly critical. The dimensions of the cuts are so small (0.0065" in width, and 0.056" in depth) that the maximum 0.0005" tolerance ordinarily expected on a conventional milling machine is a relatively large variation

* *Page* 413 of this issue.

Fig. 2—K. E. Schukraft, precision instrument and tool maker in the Murray Hill Precision Shop of the Laboratories, adjusts the milling machine for cutting the resonator slots.

*Fig. 1—**Above**, actual size of the resonator block for the 50,000-mc special harmonic amplifier for extremely high frequencies. **Below**, part of the slotted section of the resonator block magnified ten times.*

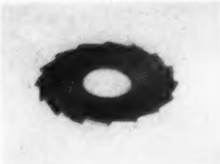


Fig. 3 – Actual size and thickness of the ¾″ diameter circular carbide saw with sixteen teeth.

(Figure 1). With such a wide tolerance, the wave reflections are excessive and interfere with the proper synchronization of waves and electrons necessary for optimum amplifying conditions for such very short wavelengths.

W. Patterson, Foreman, and K. E. Schukraft (Figure 2), precision instrument and tool maker, in the Murray Hill Precision Shop of the Laboratories, realizing that the

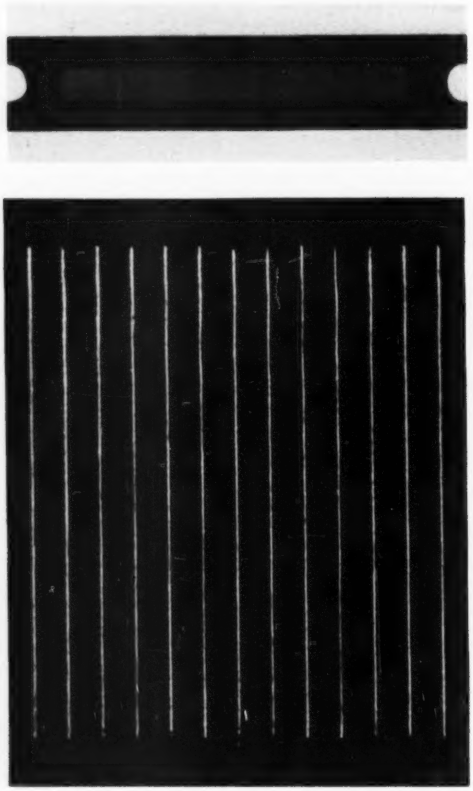


Fig. 4–Above, hairlines engraved on a brass plate, used as a guide in milling the slots. The plate is evident in Figure 2 just below the microscope. Below, hairlines magnified to appear as the milling machine operator sees them through his microscope.

utmost precision in milling is essential to the effectiveness of the wave guide, set out to improve the machining process. First, to minimize burring and to improve machinability the copper was work hardened by rolling. Then, after the longitudinal slots were cut, they were filled with stick shellac to prevent the bending of the walls when the transverse cuts are made. Next, satisfactory cutters had to be found. Chips clogged the teeth of standard saws so that the cuts were uneven, yet a single tooth cutter dulled too rapidly. In the latter case, if the cutter were removed for sharpening, the depth of the slot and the line of cut might be shifted as much as 0.001″, excessive variations in both cases. The final choice was a ¾″ diameter carbide circular saw. Its sixteen teeth do not clog, yet they will cut all 100 slots without being too much dulled (Figure 3). The saw was lapped hollow to provide clearance toward the center. In the whole operation the radius of the saw is reduced only by 0.0005″ and a tapered parallel is placed under the resonator block to compensate for this wear. Thus, the depth of cut will vary only negligibly. The saw passes through a brush containing oil for lubrication and a jet of air is directed on it to prevent chips from being drawn back into the machined portion of the slot.

But the shift of the machine table from one cut to the next still was controllable only with 0.0005″ tolerance, so that the distance between centers varied far too much. This difficulty finally was overcome with an optically indexed precision scale (Figure 4, above). Hairlines barely visible to the naked eye are engraved on a brass plate with an ultra-precision Swiss-Geneva layout machine.

Before the operation is started the machine is permitted to idle in order to expand all parts fully. Then the crossbars of the microscope attached to the guide are centered on the lines of the scale (Figure 4, bottom). The milling cutter is moved across the resonator block to cut a slot precisely as delineated by the template hairlines centered in the microscope.

With this highly refined technique the

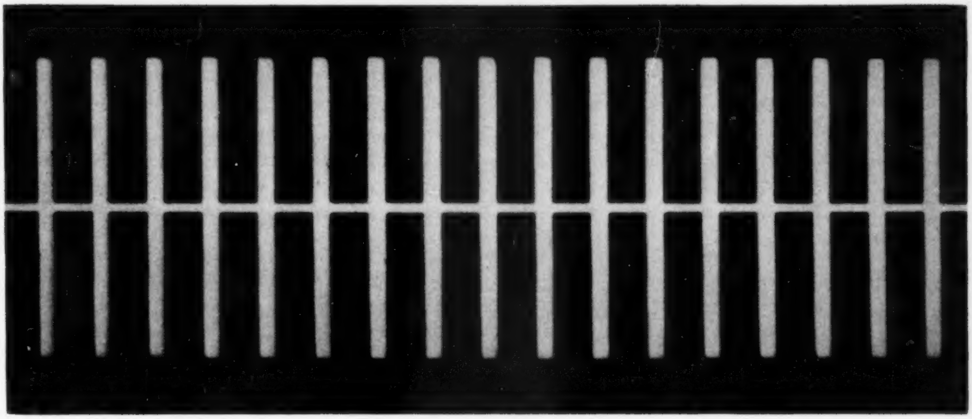


Fig. 5–The view which appears on the screen of a contour measuring projector when two resonators are placed so that their tops face each other and are magnified twenty-five times. The photograph shows the test for reliability and reproducibility. The black rectangles are the portions of metal between slots; the vertical white lines are slots; the horizontal white line is the space between the two resonator blocks. Note that the width of the vertical white lines–which is the width of the slots–shows no apparent variation between the upper and the lower resonator blocks, and that the matching proves there is no difference in distances between centers.

precision of milling has been increased by a factor of about five. In addition, the reliability of fabrication and the reproducibility have been improved (Figure 5). One satisfactory resonator block out of five was originally considered a good result. With the new techniques almost every block started is successfully finished.

J. R. Townsend Honored

J. R. Townsend, who was loaned as a Consultant to the Director of Defense Mobilization for a period of six to twelve months, has completed his assignment, but will be retained as a Consultant to the Director.

In a letter to Mr. Cleo Craig, President of the A T & T, Henry H. Fowler, Director of the Office of Defense Mobilization, stated "those of us responsible for directing the program of our mobilization effort owe to you and your organization a debt of gratitude for your generous loan of the services of Mr. Townsend for the past eight months as Conservation Consultant to the Director of Defense Mobilization. I request that Mr. Townsend remain in an occasional consulting relationship with this office which will permit our calling on him to advise us on problems originating here." In a reply made by M. J. Kelly, he stated "it is always pleasing to hear that members of our staff have done good service in their assignments in Washington. We shall be pleased to make as much of his time available as you may require in the period of transition while his replacement is becoming familiar with the task and to continue, as you suggest, an occasional consulting relationship with your office."

On Tuesday, September 23, Mr. Townsend addressed the National Advisory Board on Mobilization Policy at the White House on Conservation of Critical Materials.

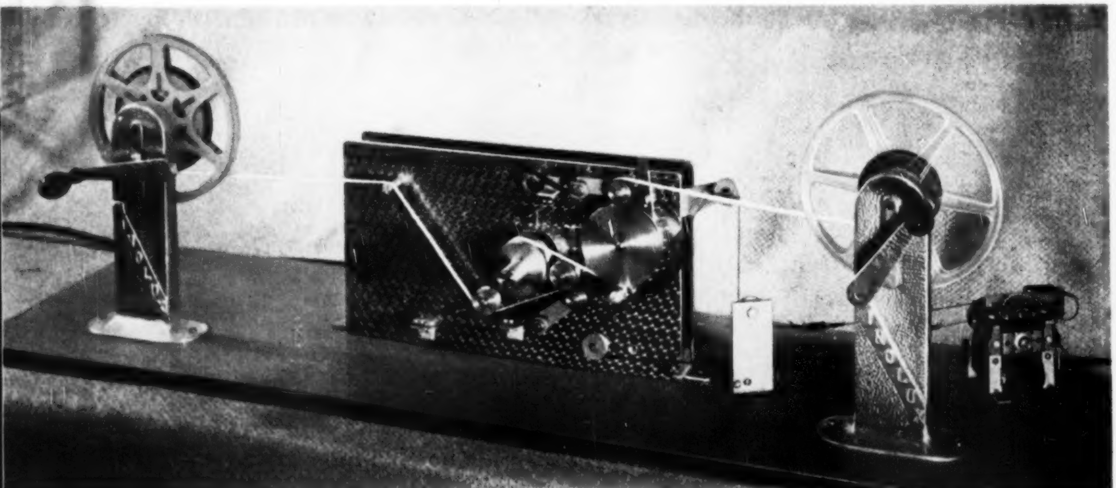
Magnetic Tape Editor

I. E. COLE
Transmission Research

In the course of a study of speech, the use of magnetic tape recording of samples has been quite extensive. This method is very convenient because it permits one to subject the same sounds to various methods of analysis over a period of time without having to rely on the memory of the speaker as to just how he spoke the particular sample. For some purposes it is desirable to be able to pick out and repeat many times a short sample of some particular sound combination, while for others it is convenient to be able to sample a whole passage bit by bit without overlapping and without omitting any material. It is also desirable to be able to handle not only whole reels of material but short lengths of tape or continuous loops.

The magnetic tape editor, shown herewith, was built to do this job. The tape to be analyzed is taken from the rewind reel at the left, passed around the pick-up wheel near the center of the rectangular plate, then around the larger drive wheel at the upper right, and thence to the rewind wheel at the right. The pick-up wheel consists of two facing flanged idler discs, and the magnetic tape, with its active surface turned inward, is supported by its edges on the flanges of the two discs. Between these discs is a standard Brush pick-up head mounted on a shaft with its pick-up gap projecting radially between the flanges and rubbing on the tape. The leads from the pick-up head are brought back through a hollow shaft to slip rings mounted in back of the panel, and the signal is fed out through a pair of brushes. While a section of the tape is being scanned, the tape is held stationary and the pick-up head rotates counterclockwise.

The maximum length of signal to be repeated was chosen to be one-half second, which is three and three-quarter inches of tape at a speed of seven and one-half inches per second, the speed of the recorders used in the laboratory. A sample of this length is enough to contain one or more recognizable speech elements or a short word. The outer diameter of the flanges on the pick-



up wheel and the angular speed of the pick-up head were selected to give a speed of scanning of seven and one-half inches per second. As a matter of convenience the diameter was chosen as 1.990 inches. This makes the arc of contact for a half second sample 216 degrees. To insure good contact, the idlers were positioned to give about 20 degrees more wrap at each end.

The scanner is driven from a motor through a rubber pinch roll, and runs continuously. To permit only the desired section of tape to be reproduced, there is a contact operated from the drive shaft that enables the amplifier at the beginning of a sample, and a timing circuit that disables it at the end of the one-half second period. An index is provided just above the pick-up wheel so that the tape may be marked at the beginning of a sample for reference in case it is later desired to repeat the sample or to cut it out.

Tape is carried forward in measured increments up to three and three-quarter inches, corresponding to one-half second of material, by the three inch pulley above and to the right of the pick-up wheel. The tape is passed around this pulley and is held in good driving contact by a rubber pinch roll. The drive pulley may be rotated by a lever coupled to it by a roller clutch that gives the effect of a ratchet with infinitely fine teeth. A similar roller clutch attached to the panel keeps the pulley from turning backwards when the lever is returned for the next stroke. Levers are also provided to release the roller clutches so the tape may be drawn forward or backward freely when desired. A scale, calibrated in hundredths of a second, is provided just to the right of this drive roller and is read opposite a pointer on the drive lever as it advances the tape.

To maintain tension on the tape while the pick-up head is rotating, a rubber-rimmed pinch roll is held against the idler roll at the right of the pick-up wheel. The idler roll is hollow and has a few coils of watch spring mounted inside it that tend to drive the rim of the roll by friction. The inner end of the spring is connected to a small sleeve held by an over-running clutch to the stationary axle. When the tape is pulled between the rolls, the spring winds up to the slipping point and then slips to maintain this fixed pull on the tape. In case it is desired to draw the tape backwards, the over-running clutch will let the roller revolve freely.

Several machines have made with modifications and attachments to adapt them to various jobs. One such is used to dub samples automatically on the storage disc of the high speed sound spectroscope*. Another has been used to pick out speech elements from which to build synthetic speech by a process of cutting, assembling, and re-recording.

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* Record, *June*, 1950, *page* 263.

THE AUTHOR: After being graduated from Sibley College, Cornell University in 1915 with an M.E. degree, I. E. Cole joined Western Electric's Engineering Department at Hawthorne. Soon afterward he came to the Laboratories where he was assigned to the telephone protection group. During World War I, Mr. Cole worked with the National Research Council on a submarine detection project. He has contributed to the development of oscillographic techniques for protection studies. He also developed the rapid record oscillograph and other devices including a light valve for picture transmission and a cathode ray oscillograph and high frequency amplifier for contact studies. Prior to World War II Mr. Cole was in charge of the development of an interpolated printing telegraph system for transatlantic radio use. He has since helped develop a "Vocoder Simulator" for the study of vocoders and other related work, and has developed the electro-mechanical parts of the high-speed sound spectrograph.

Tracing Time Backward In AMA

A. E. JOEL, JR.
Switching Systems Development

In central offices operating under the automatic message accounting system*, the entries pertaining to calls are perforated in the AMA tapes in their proper time sequence. The initial entry, containing the basic information for identifying the call, will be perforated first, then the time the called subscriber answered, and finally the time of disconnect. In the accounting centers where these tapes are processed, on the other hand, they are read backwards. Of the three entries pertaining to any one completed call, the disconnect entry will be read first, the answer entry next, and the initial entry, last. An advantage in processing in reverse order is one of convenience in tape handling: the free ends of the tape on the reels received at the accounting center from the central office can be fed directly into the first machine–the AMA assembler. For subsequent machines, the intervening splicing and rereeling routines set up, preserve the reverse order. There are, however, more basic reasons.

When, for example, the check circuits in a central office detect that an error may have occurred in the perforation of an entry, they cannot erase what has already been perforated, but they can and do provide a subsequent cancellation or correction entry. By reading in reverse at the accounting center, this warning entry is encountered first, and the machine thus knows in advance how to act when reading the entry with the suspected error.

In Figure 1, for example, is a sequence of entries in the order in which they might have appeared on an AMA tape. This tape was perforated from top to bottom: the (g) entry was perforated first, the (f) entry next, etc. At (c) is an initial entry that was suspected of being faulty by the central office circuits. As a result, a cancellation entry, (b), was perforated immediately afterward. When the tape reaches the accounting center, it is read backward, that is, in the order (a), (b), (c), etc. The (b) entry is thus encountered before the (c) entry, and thus the accounting center machine will know how to deal with a faulty entry when it reaches it.

There are, however, two other important advantages from reading the tape backward by the AMA computer. With this order of reading, the disconnect time and the answer time are both read before the initial entry, and thus the answer time may be subtracted from the disconnect time while the initial entry is being read from the tape. A set of three such entries for the same call is shown at (d), (e), and (f) of Figure 1. They were perforated at the central office in the order (f), (e), (d), but they are read after assembling it in the accounting center in the order (d), (e), (f), and thus the timing entries may be processed while the initial entry is being read.

By reading the tape backward, it is possible also to recognize the initial entries of calls without timing entries (calls to busy lines, unanswered, or free calls) immediately upon reading the first line of the initial entry and thereby avoid the further registering and analyzing of the entry by the AMA computer. Such an initial entry is shown at (g) of Figure 1. Since the immediately preceding entry was also an initial entry, the absence of intervening disconnect and answer entries shows that (g) was unanswered, and it may be discarded.

As a result of reading the tape in the reverse direction, however, the progress of time must be followed backwards. Time manifests itself in two ways in the results of the AMA process. First, there is the elapsed time on the messages, which is used directly for charging purposes, and second there is the date and time of day

* A bibliography of articles on the AMA system is given on page 428.

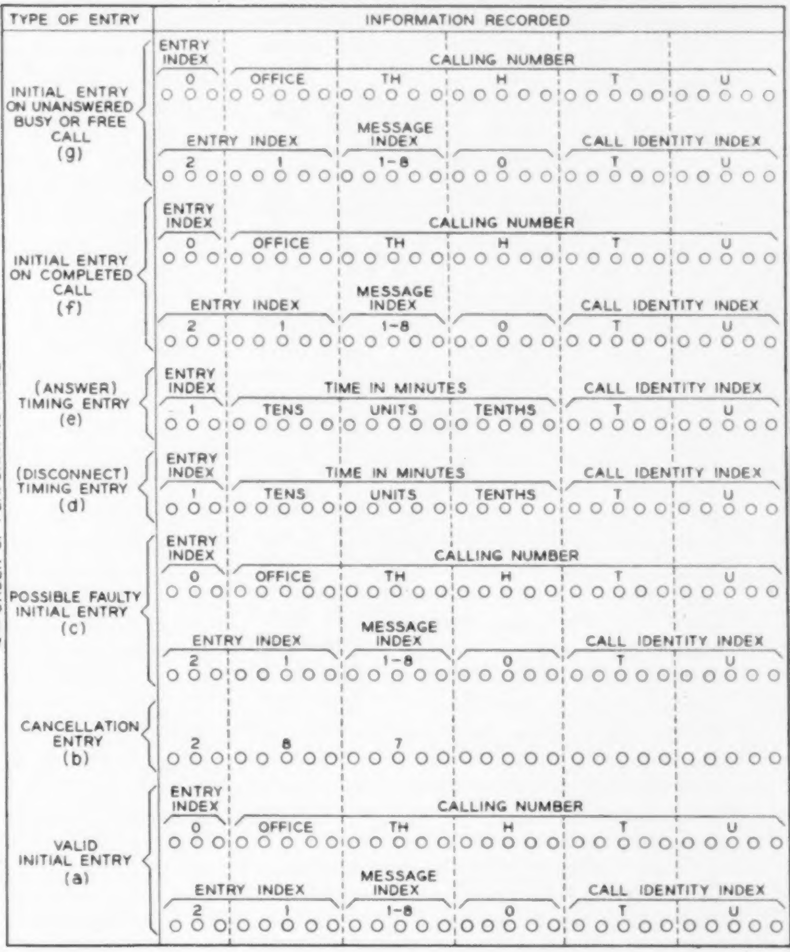

Fig. 1—A sequence of entries of various types that might appear on an AMA tape.

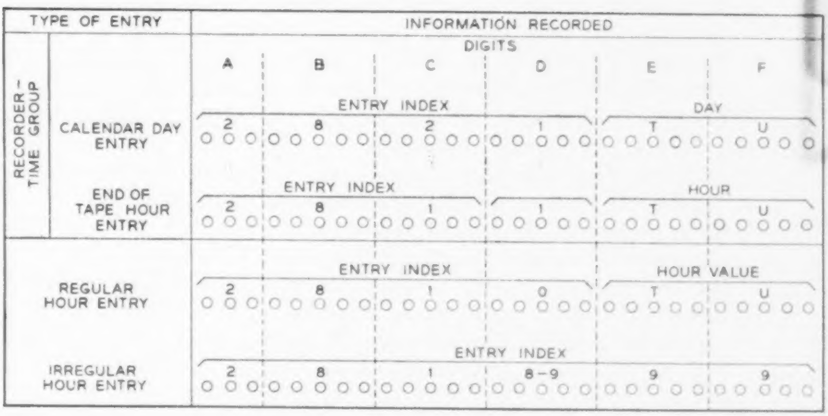

Fig. 2—Various types of hour and day entries that appear on the AMA tapes.

each call is answered, which is provided on detail-billed records for determining the rate and for use in any discussion of the call with the customer.

The principal accounting machine involved in these uses of time is the AMA computer. All entries recorded on the central office tape for individual calls are brought together by the AMA assembler. The answer and disconnect timing entries indicate only the minutes of the current hour. Interspersed among these call entries are the single-line hour entries, which are perforated each hour in the central office tape. These identify the hour by tens and units digits, which appear as the E and F digits on the tape, while the entry index 2810 occupies the A, B, C, and D digits. There are also two other hour entries known as "irregular hour entries" which have entry indexes of 2818 and 2819, and a 9 as the E and F digits. In addition, there are the end-of-tape entries which also include an hour entry with an entry index of 2811. These latter entries were originally perforated in the central office but have been copied on the output tape of the assembler. Unlike the regular hour entries, they do not indicate a change in the hour, and thus they are treated differently from the regular hour entries by the computer. These various types of hour entries are shown in Figure 2.

One or more of these hour entries may, of course, be found between the disconnect and initial entries pertaining to any one call and will thus affect the hour to be associated with the tens and units minutes digits of the answer and disconnect times. The computer must thus maintain a correct record of the hour at all times, and this it does with the hour circuit. A schematic of the hour circuit is shown in Figure 3.

This circuit consists of two principal registers: the "earliest hour register" and the "disconnect hour register." Associated with these are several connectors and subsidiary registers and an hour-counter circuit. Since the tape is read by the computer in the reverse time order, each regular hour entry received will be the hour following the hour that applies to the call entries read from the tape before the next regular hour entry is encountered. Thus prior to reading a disconnect entry that occurred at 9 hours 52.6 minutes, the computer will have read the hour entry 10. The call entry includes only the minute figures 52.6, and for the proper computation of the charges on the call the hour 9 must be associated with them. Since the previous hour received by the computer was 10, an important part of the hour circuit is a "less one connector," which subtracts one from each regular hour entry before registering it.

A schematic of this "less one connector" circuit is shown in Figure 4. At the right are the ten units leads and the three tens leads from the reading relays, and at the left are the equivalent output leads that go to the earliest-hour register. Each time a regular hour entry recorded on the reading relays is to be transferred to the earliest-hour register, ground is placed on the lead marked 2810 at the right of Figure 3 and on one each of the units and ten leads. Ground on the 2810 lead operates the HO relay and also—if relay CTO is not operated—operates the NC relay. None of the other relays will operate except for input hours 00, 01, 10, 11, 20, and 21. Under these conditions, the hour appearing on the output leads will be one less than that on the input leads. By the operation of HO each input units digit is connected to the next lower digit lead on the output side, and each tens digit input lead is connected to the same valued output lead.

When the input hour is 00, 01, 10, 11, 20, or 21, however, the translating procedure is a little different. When the input units digit is 1, and the tens digit is not 0, such as 11, or 21, the NC relay is operated at the same time as the HO relay, and the translation is to one lower number on the output leads as before. Thus 11 is translated to 10, and 21 to 20. Ground on the 0 lead of the units output group, however, operates relay CTO. This causes no change at the moment because NC holds itself operated, and CT cannot be operated because of an open back contact of NC. When the reading relays are subsequently disconnected from the less-one connector, however, HO and NC release but CTO remains operated until after the reading relays have been again connected to the less-

one connector to record the next hour entry. When this occurs, since CTO is now operated, NC will not operate because operating circuit is open at CTO. Instead relay CT will operate, and thus the output leads will record 09 or 19 with input 10 or 20.

When the input hour is 01, relay NC will operate with HO as before, and the translation will be made to 00. After the HO and NC relays have been operated, however, both CTO and CTU will operate because of the grounds on the 0 units and 0 tens output leads. Both of these relays hold operated after HO and NC have released, and thus when the reading relays are connected through for hour 00, relays CTU1

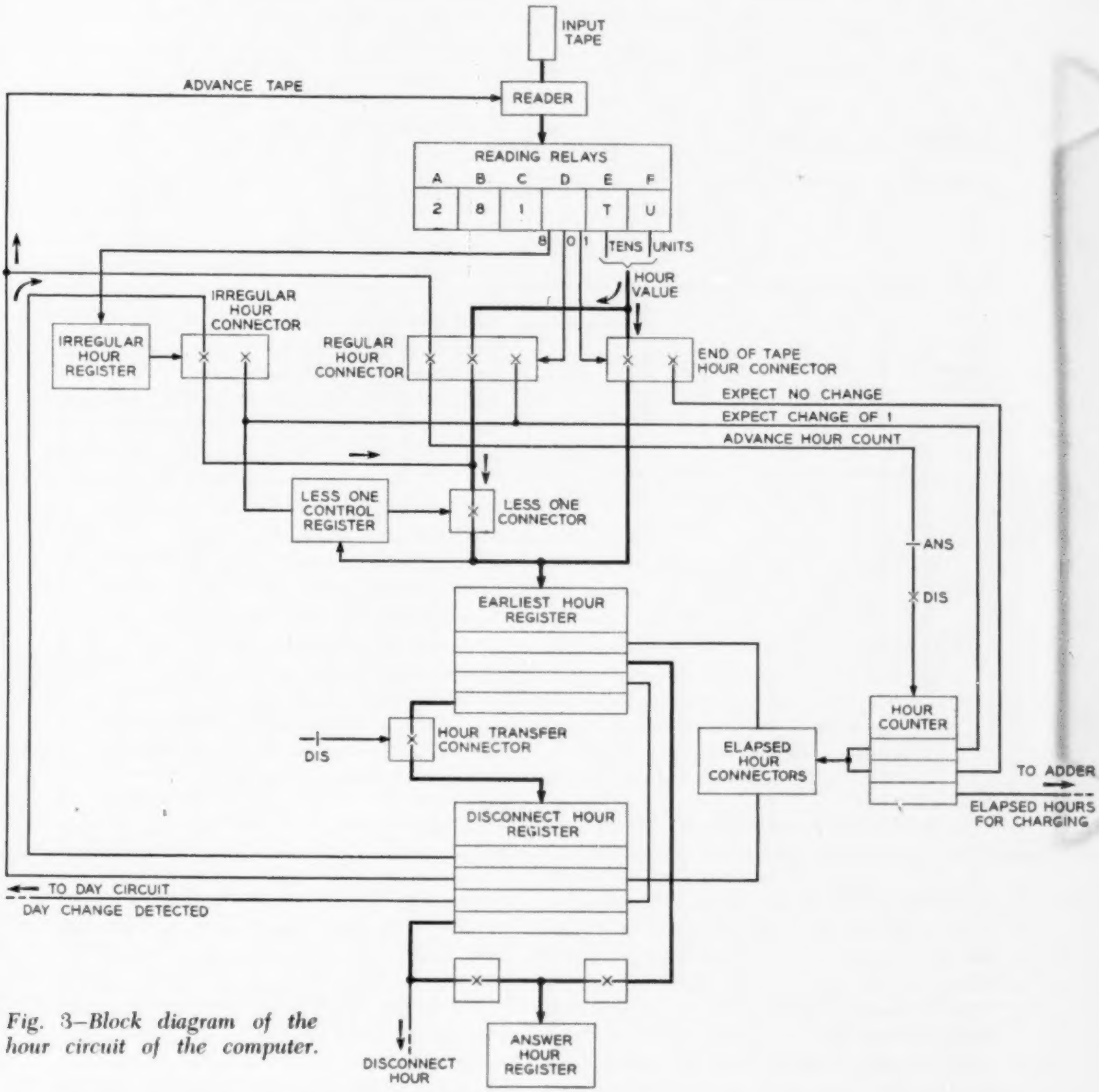

Fig. 3—Block diagram of the hour circuit of the computer.

and HO will operate simultaneously. With CTU1 operated, the input 00 is translated to 23 at the output. This scheme of operation and translation is shown in Table I.

When beginning the processing of a new tape, an end-of-tape hour entry is the first hour entry received. It is identified by the entry 2811, and when such an entry has been recorded by the reading relays, the end-of-tape hour connector is operated. The E and F digits of the reading relays are transferred to the earliest hour register through the end-of-tape hour connector instead of passing through the less-one connector. Since there is no hour value registered at this time in the disconnect hour register, the hour value in the earliest hour register is immediately transferred to it. Since this entry is made after a regular hour entry, it will be correct for application to call entries read subsequently because the tape is read in reverse time sequence. With an end-of-tape hour entry made at 3:30 A.M., for example, the hour value will be 03. This hour will be correct for all call entries made during the preceding half hour, and this—since the tape is read backwards—for all calls encountered prior to the next regular hour entry. The end-of-tape hour entry recorded on the earliest hour register is, therefore, immediately transferred to the disconnect hour register, and the earliest hour register is released after a check is made that the hour value now in the disconnect hour register agrees with the earliest hour value recorded.

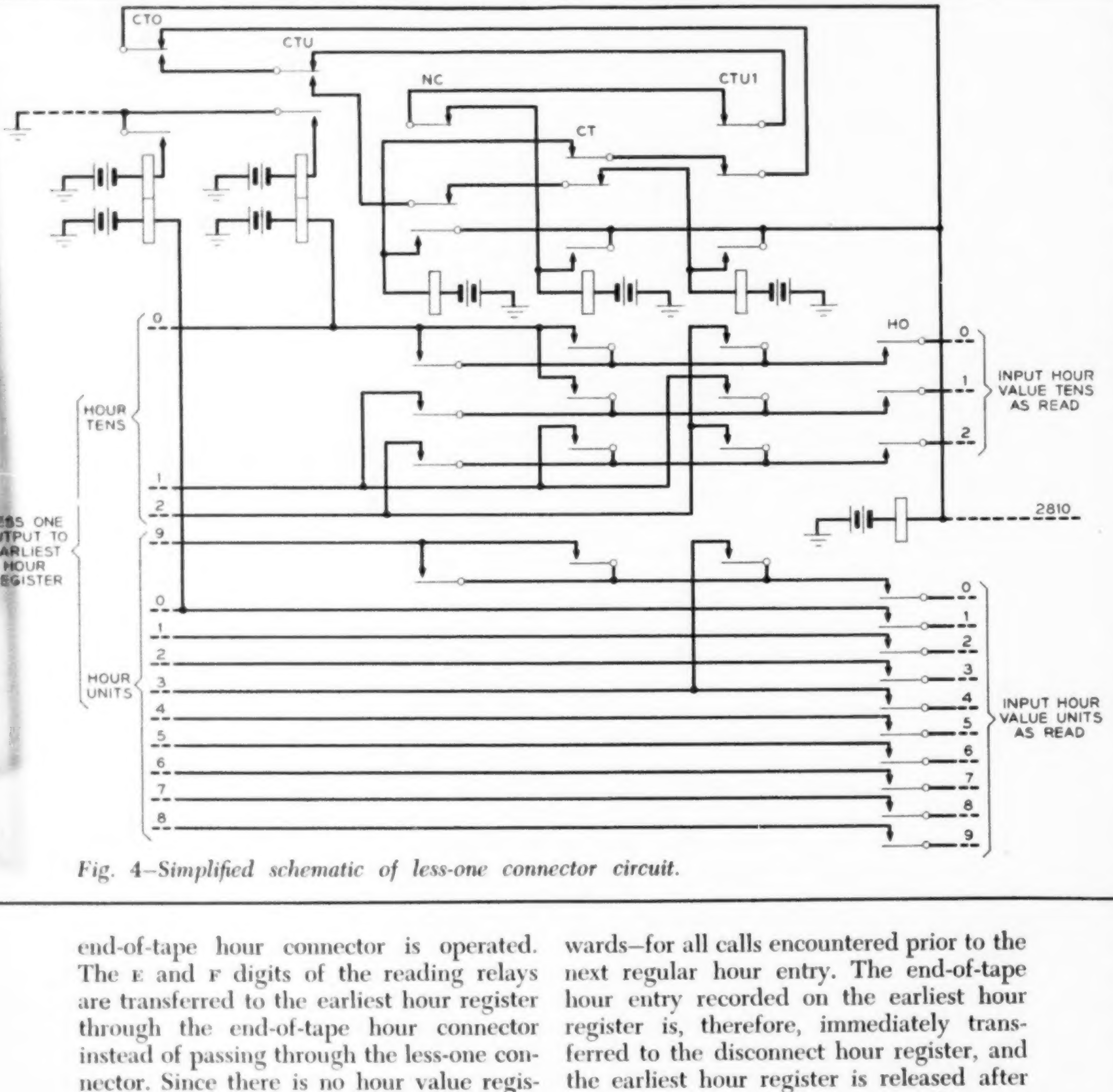

Fig. 4—Simplified schematic of less-one connector circuit.

Whenever the reader of the computer encounters a 2810 entry index, indicating a regular hour entry, and has recorded the entry on the reading relays, the regular hour connector is operated. This connects the E and F digits of the reading relays through the less-one connector to the earliest hour register.

Each time an hour has been recorded in the earliest hour register, the hour counter circuit checks it against the hour recorded in the disconnect hour register, and then, if the difference between the two registers is correct for the conditions, allows the reader to advance to the next line. At this time also the hour will be transferred from the earliest hour to the disconnect hour register, unless a call entry has been received in the meantime. Once the first, or disconnect, timing entry has been read from the tape and stored in another part of the computer, the hour circuit is prevented from performing the transfer of the hours from the earliest hour register to the disconnect hour register. The hour circuit is then arranged to start counting the hours whenever a regular hour entry has been registered in the earliest hour register and checked.

Should it happen that a regular hour entry be received prior to the receipt of the answer timing entry on this call it would be registered – less one – in the earliest hour register and checked. At the same time the hour counter would count one hour, and this count would change the number of expected elapsed hours should another hour appear before the answer timing entry is received. As long as one timing entry has been registered, the succeeding hourly entries are registered only in the earliest hour register–each new one displacing an old one. It is for this reason that it is called the "earliest hour register," since during a call it contains the earliest hour value that has been received and interpreted by this circuit. The disconnect hour register contains the hour value as it was at the time that the disconnect timing entry was received. If new hour entries are received by the earliest hour register the elapsed hour connector is arranged to expect the difference between the earliest and disconnect hour register in accordance with the hour count thus far recorded. The advance of the hour counter when registering new earliest hours during a call is permitted only after the elapsed hour check has been made on the value as received.

When the answer timing entry is read from the tape, all hour counting ceases since the hours counted between the disconnect and answer timing entries are the only ones to be used in the computation of the elapsed time. At the same time the answer hour register is used to record the hour value at the time the answer timing entry was read. If no hour occurred between the disconnect and answer timing entries the answer hour registration is taken from the disconnect hour register. If, however,

TABLE I–TABULATION OF RELAY OPERATIONS IN THE LESS-ONE CONNECTOR CIRCUIT

Input Hour	*HO*	*CTO*	*CTU*	*NC*	*CT*	*CTUI*	*Earliest Hour Register*
01	x			x			00
		x	x				
00	x	x	x			x	23
23	x			x			22
22	x			x			21
				x			20
21	x	x					
20	x	x			x		19
19	x			x			18
12	x			x			11
11	x			x			10
		x					
10	x	x			x		09
			x				
09	x		x	x			08
			x				
08	x		x	x			07
01	x		x	x			00
		x	x				
00	x	x	x			x	23

one or more hours have intervened between the disconnect and answer timing entries, then the answer hour is to be found at this time in the earliest hour register.

The result of the hour count is passed on to the portion of the computer where elapsed time is calculated. The hour counter is arranged to count a maximum of only three hours since calls with more than three elapsed hours are beyond the capacity of the elapsed time calculation. On such calls it is necessary to obtain both the answer and disconnect hour values from the hour circuit. The answer hour is registered as previously described and the disconnect hour is taken directly from the disconnect hour register.

Means are provided in the central office for placing entries on the tape to indicate that difficulty is being experienced in placing the proper hour value on the tape for the regular hourly entries. In this case irregular hour entry 281999 will appear on the central office tape and is passed to the accounting center for correcting the information in the hour circuit. The 281999 irregular hour entry indicates that a difficulty was experienced in recording the regular hour entry and that what has been recorded should be skipped. This skipping operation was performed by the assembler which in turn placed an 281899 irregular hour entry on its output tapes. This entry may appear on the central office tape if an equipment trouble prevents a regular hour from being perforated, and the assembler reperforates the entry without change. The computer in receiving an irregular hour entry 281899 first registers this fact in the irregular hour register. If there is no call in the computer circuit at this time, the earliest hour register is nor-

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Bibliography of Bell Laboratories Record Articles on AMA

Automatic Message Accounting, *C. F. Seibel* . . . . September 1951, page 401

Basic AMA Central Office Features, *D. H. Pennoyer* . . . . . . October 1951, page 454

The AMA Tape Perforator, *P. B. Drake* . . . . November 1951, page 504

No. 5 Crossbar AMA Translator, *T. L. Dimond* . . . . February 1951, page 62

Recording on AMA Tape in Central Offices, *D. H. Cahill* . . . December 1951, page 565

The AMA Timer, *W. C. Jordan* . . . . March 1952, page 122

Code Patterns in Telephone Switching and Accounting Systems, *J. W. Dehn* . . . . January 1952, page 9

Central Office Equipment for AMA, *P. W. Sheatsley* . . . . April 1952, page 173

Basic Features of the AMA Center, *John Meszar* . . . . . . February 1952, page 70

The AMA Reader, *F. C. Kuch* . . . . June 1952, page 237

The AMA Assembler, *Glen G. Drew* . . . . May 1952, page 227

The AMA Computer, *A. E. Hague* . . . . July 1952, page 289

Tracing Time Backward in AMA, *A. E. Joel* . . . . November 1952, page 422

The Sorter for AMA, *F. N. Rolf* . . . . July 1952, page 299

The AMA Summarizer, *George Riggs* . . . . August 1952, page 321

The AMA Printer, *T. A. Marshall* . . . . September 1952, page 368

Test Tapes for AMA, *L. A. Kille* . . . . September 1952, page 349

A Test Unit for AMA Perforators and Readers, *A. R. Bonorden* . . October 1952, page 398

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mal and the irregular hour register takes action to connect the output of the disconnect hour register through the irregular hour connector and the less-one connector to the earliest hour register. In this way the hour circuit boosts itself by its own boot straps to produce artificially from the hour already registered, the new hour which was missing or mutilated on the central office tape.

If a call is in progress, the irregular hour register is prevented from performing this self-correcting action since the disconnect hour may not be the succeeding hour value. In this case the irregular hour register controls the hour circuit so that it may be brought up to date when the next regular hour is read from the tape. When the next regular hour value is read between the disconnect and answer timing entry, the irregular hour register arranges the controls so that the regular hour entry is first read in as an end-of-tape hour without subtracting one. This in effect brings the hour registration up to date and will permit the proper subtraction of one hour from this hour value when it is next read through the regular hour and less-one connectors. In this way once again the hour circuit lifts itself up by its boot straps so that the correct hour progression passes through the earliest hour register and the correct subtraction can be made.

The end-of-tape hour entry is perforated on the tape at the central office and reperforated by the assembler on the tape that goes to the computer. Such an entry is placed on the tape each day between 3 and 4 a.m. to provide the time information at the point where the tape may be cut for transmission to the accounting center. These entries may also appear on the tape at any point where regular recording was stopped or restarted. In this case further recording is usually continued by an emergency recorder on a different tape section.

Should end-of-tape hour entries occur during processing, the first of these to be received is checked to see that it agrees with the previously registered hour. In this case the elapsed hour connector expects no change in the hour value. Succeeding end-of-tape hour entries are registered without checks since they may be the start of new processing which takes place after a central office trouble of indefinite length.

The timing and dating of calls requires the day and month to be traced backward in much the same manner as described above for the hour records. For this purpose a day circuit is provided in the computer which together with appropriate portions of the tape identification circuits insures that the correct calendar day appears on all detail call records. The hour circuit aids in this function by providing the day circuit with an indication when the midnight hour entry is registered. The AMA printer and tape-to-card converter also must interpret the calendar day and tape identification records to print or control the punching of the proper month value.

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Handling Coin Calls in No. 5 Crossbar

C. E. GERMANTON
Switching Systems Development

Outgoing trunk circuits perform a number of functions such as supplying talking battery to the originating subscriber, recognizing disconnect and supervisory signals, and operating call charging equipment. The amount of equipment they require depends on the service or services being given. An outgoing trunk circuit used in completing calls for flat-rate subscribers only, for example, requires a minimum of equipment, while a trunk circuit which completes calls on a message-rate basis requires more, and one which completes calls from coin box stations requires still more. A coin outgoing trunk circuit that takes care of overtime charges as well as the initial coin charge requires eight relays and an expensive timer in excess of the equipment that is required for a flat-rate trunk circuit. An average office of say 10,000 subscriber lines may require as many as 400 outgoing trunks, divided into many small groups. Since usually only a small percentage of the total outgoing traffic originates at coin stations, economical operation requires that as few as possible of the outgoing trunks be equipped with coin features.

An obvious method of reducing the number of outgoing trunks equipped for coin service would be to divide the trunks to a terminating office into groups according to the class-of-service of the originating customers. The trunks could thus be divided into three groups, serving flat-rate, message rate, and coin customers, respectively. Another possible arrangement would be to divide the trunks into two groups, one group serving coin customers and the other serving all other customers. Although such arrangements would reduce the equipment cost per circuit, they have serious disadvantages, since they reduce the effective sizes of the trunk groups, and thus lower their efficiency. To compensate for the lower efficiency, more trunks are required. This disadvantage is compounded, since the greater part of the cost of most trunks is in the cable or outside plant rather than in the relay circuits itself.

A method has recently been devised, however, for avoiding this difficulty in No. 5 crossbar offices by the use of coin junctor circuits.* In this way the expensive coin handling features can be made available on calls to all needed destinations without sacrificing the efficiency of the trunk groups. When coin junctors are used, the outgoing trunks are arranged to handle directly all traffic except coin. For coin calls a coin junctor is switched in series with the outgoing trunk circuit. Thus, there need be only enough coin junctors to handle the coin traffic, and there is no loss in trunk efficiency since all the outgoing trunks are available for all calls.

The use of coin junctors not only saves the additional equipment that would otherwise be required in a large number of the trunks, but it also saves many vertical units in the coin supervisory links. Each coin trunk must have access to a coin supervisory circuit through one vertical unit of a cross-

* This method was suggested independently and concurrently by Bell Telephone Laboratories engineers and by Mr. Warren Turner, Jr., of the New Jersey Bell Telephone Company.

bar switch on the coin supervisory link. When coin junctors are used, each junctor also requires a vertical on the coin supervisory link, but since there are fewer junctors than outgoing trunks, there will be a saving in coin supervisory links.

It must not be assumed that the advantages of coin junctors outlined above are obtained without some sacrifice. A junctor call, for example, requires switching through the office twice, as will be brought out later. As a result, there are some situations in which it is economical to provide direct coin trunks to one or more offices, even though a large portion of the coin traffic is handled through junctors. When, for example, there is an appreciable amount of coin traffic to a particular destination, it may be more economical to have a group of high usage coin trunks to that office. These direct trunks would handle most of the coin traffic while the coin junctors would take the overflow to that office as well as the entire coin load to other points. It is obvious that this arrangement could also be used for routes through tandem.

The coin junctors are associated with the No. 5 switching circuits in much the same way as tandem trunks. Each junctor has an appearance on both a line link and a trunk link frame, and in addition has access to outgoing senders and incoming registers. The arrangement is indicated in Figure 1. This shows the use of direct coin trunks as well as coin junctors, but in illustrating the method of using the junctors, it may be assumed first that there are no direct coin trunks.

When a coin customer, under these conditions, originates a call, a marker connects his line through a line link and trunk link frame to an originating register, where his call is recorded. The register then calls in a marker which connects the calling line over path "a" of Figure 1 to an idle coin junctor, associates an outgoing sender with the junctor, and transfers the called number from the originating register to the sender. The sender then signals the junctor to call in an incoming register. After the register has been connected, the sender pulses the number to it, and then releases itself from the connection. The incoming register, acting as it does on tandem calls passing through the office, calls in a marker to establish path "c" through the line link and trunk link frame to an outgoing trunk. A sender is connected to the outgoing trunk at the same time, and the marker transfers the called number to it from the incoming register. The incoming register is then released, and the sender, which has been connected to

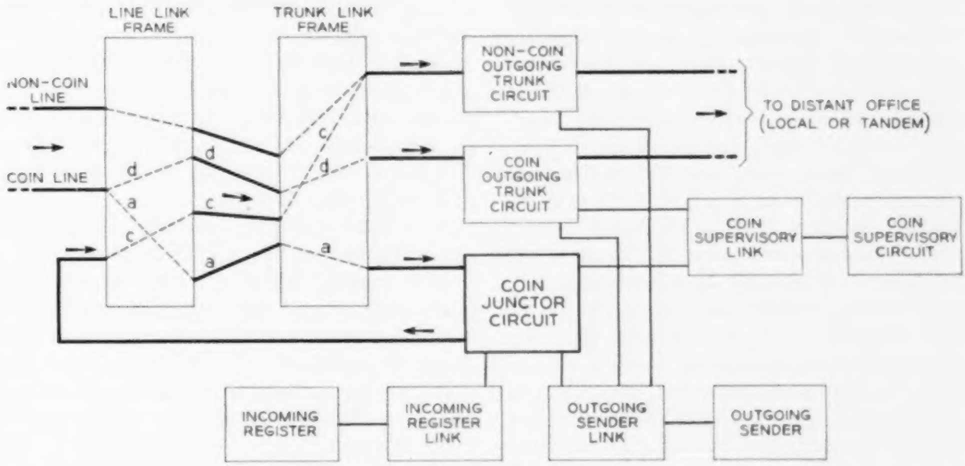


Fig. 1—Block diagram indicating method of associating coin junctors with non-coin trunks in the No. 5 crossbar system.

the selected trunk, pulses the number over it to the terminating office.

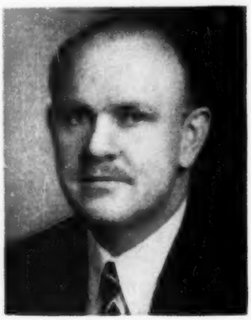
If the offices were provided with some direct coin trunks as well as coin junctors, as indicated in Figure 1, the marker, when called in by the originating register, would have attempted to complete the call directly to a coin trunk. If an idle coin trunk were available, the connection would have been set up to it as indicated by path "d," and a coin junctor would not be required. Had all the coin trunks been busy, however, the marker would have connected the call to a coin junctor over path "a," and the call would have proceeded as has been already described.

Traffic patterns are subject to unpredictable change. A residential section of a community, for example, may become a business and theater center, its telephones then changing from flat rate to coin and message rate. To provide the flexibility required to meet such changes, the coin junctors have been designed so that they can be used either as coin junctors, or coin interoffice outgoing trunks. All that is needed to change from one type of operation to the other is a change in a few cross connections, and these may be made at the main distributing frame. Should an office have originally only a small amount of coin traffic and be equipped with coin junctors and no coin outgoing trunks, it could at any time be converted to have both coin junctors and coin trunks by converting some of the junctors at the main frame. This is desirable when there is enough coin traffic to keep the coin trunks busy most of the time, since it decreases the load on the switching frames, and particularly on the incoming registers and markers.

The junctor method of operation is proving to have a wider scope than coin traffic alone, and has already been used by some companies in connection with AMA trunks. Just as all coin trunks require a vertical unit on the coin supervisory link to permit them to be connected to a coin supervisory circuit, so all AMA trunks must have access to call identity indexers and recorders. When an office has a comparatively small amount of AMA traffic, it is more economical in equipment to provide circuits equivalent to the coin junctors, thus reducing the number of circuits with access to the recorders and call identity indexers. Any of the regular trunks could then be used for AMA calls by associating them with one of these junctor circuits.

This broadening of the field of junctor operation points up still further possibilities. If message rate traffic is low enough percentagewise, it also may justify the use of junctor operation. With the growing tendency to widen the dialing scope for coin and message register lines, there will be an additional field for application of the junctor principle.

THE AUTHOR: C. E. GERMANTON was graduated magna cum laude from Lafayette College in 1926, receiving the B.S. degree in electrical engineering. He then joined the Technical Staff of these Laboratories where, as a member of the Systems Development Department, he has since been principally engaged in the development of panel and crossbar switching circuits. During World War II he contributed also to the design of operational flight trainers, which were built by the Western Electric Company for the Navy. Since V-E Day he has been designing circuits for the No. 5 crossbar and Centralized Automatic Message Accounting systems.



High Stability 100-Kc Crystal Units for Frequency Standards

J. P. GRIFFIN
Transmission Apparatus Development

The first quartz crystal clock was developed and built by Horton and Marrison in 1927. Its frequency controlling crystal unit consisted of a 50-kc X-cut rectangular block of quartz supported between two heavy metal pole pieces as shown in Figure 1. Very gratifying results were obtained from this type of crystal unit, but many possibilities for improvement became evident as time passed. Among these were crystal temperature control, more advantageous cuts, and better mounting methods –all tending toward greater constancy in frequency and higher vibrational efficiency.

These advances led to the development of the now familiar quartz ring crystal shown in Figure 2, which was used in the Bell System frequency standard oscillator up until 1937. This crystal has a zero temperature coefficient of frequency at about 40 degrees C on an approximately parabolic curve. Temperature control and mounting refinements made possible by the ring-shaped crystal resulted in oscillation stabilities well beyond anything previously realized in any time-standard devices, including the finest gravity pendulum clocks, even though such clocks are accurate to 0.0025 seconds a day.

When W. P. Mason discovered the new GT-cut, the art was again free to advance. This crystal plate derives its excellent characteristics from a particular angular orientation and dimensional ratio. Its temperature coefficient, instead of being zero at only one temperature, remains essentially zero over a wide range of temperatures as a result of a cancelling effect between two coupled modes with opposite characteristics. The crystal was prepared in the form of a thin rectangular plate equipped with metallic electrode coatings and mounted in a holder that supported the plate between two centrally located pressure-point contacts as shown by Figure 3. Experience with these pressure-type mountings during the next several years, however, showed them to be insufficiently resistant to mechanical shocks, and proved that they were difficult to manufacture.

In recognition of these shortcomings and in accord with the advancing crystal art, the pressure-type mount was replaced in 1938 by the now familiar wire-supported type in which the plate is suspended in a protective cage and housed in an evacuated metal container. This new unit, coded the 85A, was used in various primary standard oscillators until the early part of World War II, when it was necessary to improve the mounting arrangement to get a more rugged unit with the better electrical characteristics required for the U. S. Navy's LORAN Ranging system. The redesigned unit, designated D-168670, is shown in Figure 4. It consisted of a wire mounted design as before, but the supporting wires were increased in size and number to give about a five-fold increase in mounting strength, and the cage structure was transferred to a glass bulb and stem assembly that offered much greater assurance of vacuum tightness than the metal bulb and soldered stem arrangement that was used on the 85A.

This new unit is easily strong enough to stand normal shipping and handling. It is impervious to change in humidity and pressure, and has a temperature coefficient of frequency of about 2 parts in 10^7 per degree C. Its quality factor, or Q, exceeds 140,000, and the frequency drift with time

is less than 1 part in 10^8, or 0.00043 seconds, per day.

Crystals of this type are used in the Bell System frequency standard and have proved very satisfactory. The National Bureau of Standards has recently expressed a need for primary standards of even greater constancy, and this need, together with the advent of higher-frequency transmission systems such as the L3 and microwave carrier systems, led the Laboratories to undertake a thorough study of all the possibilities of improving the behavior of quartz crystal units for primary standard oscillators. Work was accordingly started in 1949 to devise 100-kc crystal units with frequency stabilities and Q's at least one order higher than currently available. Other objectives were

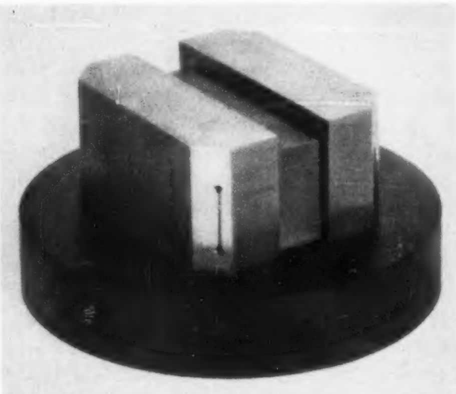


Fig. 1—The 50-kc crystal mounting used for the first crystal clock.

better temperature coefficients of frequency and resistance, and greater stability of frequency and resistance with driving current. These lesser items need attention because of limitations in oscillators and crystal ovens.

Crystalline quartz is inherently a very stable material but in the completed crystal unit there are a large number of factors which affect the frequency stability. The principal ones are listed below:

1. The silver paste spots applied to the plate for the purpose of mounting wire attachments are in an area of maximum stress. As a result, variations in their consistency may result in frequency changes.

2. Since the evaporated electrode coatings alter the mass and elastic response of the crystal, the adherence and disposition of the plating can influence performance.

3. The process of edge grinding the plate to adjust the primary and secondary frequencies can cause chips and cracks that result in poor stability with respect to time and amplitude.

4. Loose quartz particles or misoriented surface layers due to grinding give a condition of instability contributing to aging.

5. Contamination such as moisture, oils, absorbed gases, or any other foreign material results in a degradation of Q and uncertainties of frequency.

6. Since the crystal plate mounting is part of the vibrating system, the frequency stability is dependent upon the quality of the mounting or support system.

7. When the mounting wires are soldered to the spots, local heating of the plate may induce strains that should be avoided. Also the solder joints themselves should be small and well located to reduce their influence on frequency and Q.

The fired silver-paste spots constitute foreign matter on the crystal, but since they are unavoidable, attention was turned to moderating their effect. Surprisingly, no relation between their number or size and performance of the crystal unit was detected. Nevertheless it was considered prudent to employ small homogeneous spots of very well mixed paste carefully fired to drive off volatile constituents before the completed unit was sealed in vacuum.

The metallized coatings commonly used on crystals consist of either sprayed and fired silver solution, or evaporated coatings of pure silver, gold, platinum, or aluminum. To achieve a homogeneous layer of silver solution with low resistance, it is necessary to apply a rather copious amount—from 10 to 12 milligrams per square inch. This is an undesirable mass of foreign material, and also is subject to variations from one plate to another. Because of these considerations, spray solutions were rejected in favor of vapor deposited films. These can easily be controlled within the limits of a few tenths of a milligram. Such coatings are applied to the crystal by evaporation in vacuum at an elevated temperature.

Platinum was rejected as impractical as a coating because several applications are required to build up a suitable layer. Silver, most commonly used, was eliminated since it is subject to contamination while the crystal is otherwise being processed into the final unit. Aluminum was found to be unsatisfactory because the solvents used in cleaning the plate after each grinding operation during adjustment destroyed the adherence of the metal to the quartz. Gold was adopted as the most satisfactory choice since films as thin as 1 milligram per square inch provide good continuity and are not only very inert but can be applied with good adherence and can withstand subsequent firing at 520 degrees C. This latter factor assumes importance during the annealing operation applied to relieve strains in the crystal.

Besides changing the material used for the coating, and its method of deposition, it seemed possible that increased stability might be obtained by using coatings with a smaller area. The amplitude of vibration of a crystal plate is greatest at the edges and least in the central portion near the nodal point. There is thus more tendency for the coating near the edges of the crystal to be thrown off, which would raise the frequency. The frequency and coefficient of GT plates are adjusted by grinding the edges, and thus there is a tendency for the plating to loosen around the periphery. Such loosened particles may come off after the unit is placed in service. This has been avoided by leaving an unplated border on the new and improved plates that have been supplied to the National Bureau of Standards.

During the processes of plating and spotting, the crystal is necessarily subjected to heat shocks that may introduce strains in the crystal plate. If such strains existed they could be regarded as temporary changes in the elastic constants of the quartz, which would eventually relax and allow the frequency to age back toward the theoretical value. This effect can be illustrated by forcing a sharp stylus against the edge of a crystal and noting the frequency drift as the pressurized area subsides when the stylus is removed. An attempt was made in the newest experimental units, therefore, to remove the induced strains by annealing.

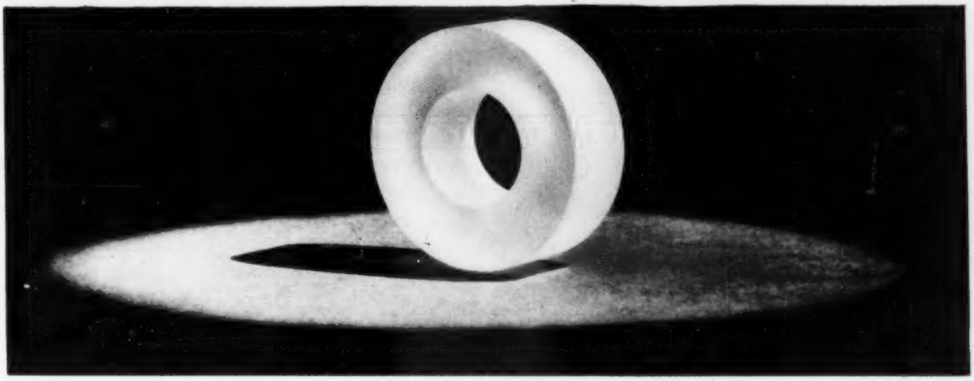


Fig. 2–Ring type crystal used for the Bell System Frequency Standard of 1937.

To accomplish this, the spotted and plated crystal was raised to 520 degrees C and then cooled uniformly at the rate of 1/2 degree C per minute for 16 hours. This annealed condition was at least partially preserved throughout the wire soldering by the aid of a precisely fitting brass box that completely enclosed the crystal and wires. The box was placed on a hot plate and heated until the solder melted. The assembly was then removed and allowed to cool. By this means the four wires were all attached at the same time at a uniform temperature of about 200 degrees C, and the heating and cooling rate could be controlled.

The next and probably most hazardous operation is adjustment to frequency by

edge grinding the crystal. The temperature coefficient is adjusted to be about one part in 10^7 per degree C by accurately grinding adjacent edges to a precisely determined width-length ratio of about 0.85940. At the same time, the resonant frequency is carefully increased to the desired value by uniformly grinding the two long edges. To attain the $\pm 1/2$ cps adjustment required on the 100-kc plates, the width dimension must be held to a tolerance of seven millionths of an inch. Crystals are ordinarily ground on a power driven lap with the plate clamped to a moving arm. To avoid the strains induced by such treatment, the crystal plates for the National Bureau of Standards were ground by hand using very fine compound on a stationary lap. This yielded finished plates without the chipped edges and corners attendant on the usual edge grinding operations. Following each

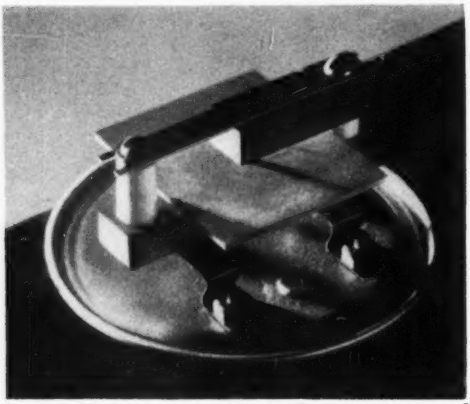


Fig. 3—Pressure point crystal mounting used for the GT cut crystals.

adjustment, the accumulated grinding debris and other contaminants are removed before any measurements are made.

Although ordinary cleaning routines are adequate for most crystal work, they do not entirely remove the fractured particles of quartz and imbedded fragments of grinding compound. The degree of refinement required for precision standards greatly increases the importance of such second order items, and therefore, following a thorough cleaning, the ground edges were restored to their original condition by etching with concentrated hydrofluoric acid. It was noticed that the rate of frequency change with etching was about one cycle per second for each three minutes of etch. This figure is so reliable that final adjustments were accomplished by edge etching rather than by grinding. Each time a crystal is ground and cleaned it is necessary to allow several hours of aging before measurement if accurate and reliable results are an important factor.

Certain variations of crystal unit performance are caused by surface conditions and mounting arrangements. Small amounts of contamination on the surfaces, particularly oil, have a marked degrading effect on the dissipation constant. W. P. Mason, in studies of supersonic devices, has shown that the energy dissipated by oil on a piezo-electric crystal varies as the cube of the thickness of the oil film. This is borne out by the fact that the highest Q is obtainable only when the surfaces have been cleaned with great care. It would seem that such variations could be decreased by increasing the volume of the crystal. The thin rectangular shape of the present 100-kc GT crystal plates follows from practical considerations of electrical design and from mounting limitations. For such a shape, an increase in thickness would yield a much greater expansion in volume than in surface area, and thus surface irregularities and contamination should have less effect on a thick plate than a thin one.

To investigate this possibility, a few plates were built with a volume three times normal. Although tests showed dissipation constants of about 3 x 10^6 and low-frequency aging of about 2 parts in 10^9 per day, these do not represent any gain over thin plates built in the same way. It was concluded, therefore, that room for improvement, if any, must lie elsewhere.

One of the most suspect items about a crystal is its mounting. The present style wherein the plate is suspended by fine wires soldered to small spots of fired silver paste has been evolved over a period of years and is considered reasonably satisfactory. Current practice for 100-kc GT plates is to support them by eight headed wires of phosphor bronze 0.008″ in diameter soldered to burnished silver spots with

183 degrees C eutectic solder using rosin flux and hot air blast. The wires are placed opposite each other in pairs on the two major surfaces along the lengthwise center line. Microscopic observation of particle motion on the crystal surface and tests with lycopodium powder, as well as experiments with different wire attachment arrangements, have shown that no clearly advantageous nodal points exist. It has been established, however, that the mounting wires must be in the central area along the length to yield best Q's. Contrary to theory, single-point mounting at the center was found to be no better than two-point mounting; hence for mechanical reasons the latter was adopted. Six-mil diameter wires and a minimum amount of solder (800 cubic mils) were accepted as moves in the right direction.

Rosin flux was rejected in favor of phosphoric acid, since the latter permits the solder connections to be made quickly and uniformly. Rosin is so gentle in action that excessive heating time is required, which tends to degrade the attachment of the spot to the plate. Acid flux is not recommended for normal commercial applications because of its possible continued corrosive action but for these carefully controlled frequency standard crystals precautions are taken to forestall any lingering effects. Another advantage of the acid flux is thorough wetting and uniform and predictable solder cones around the headed wires.

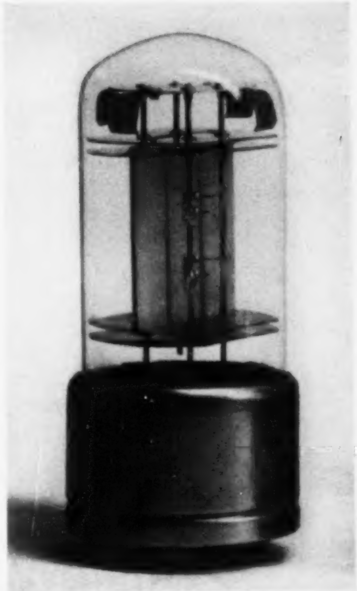


Fig. 4—The wire supported crystal used for the Navy's LORAN ranging system.

Destructive pull tests have shown pull-off strengths of about 1250 grams. Some units assembled two years ago with acid flux were examined microscopically for evidences of corrosion but none appeared. This is not surprising because only a very small amount of flux is needed and the residue after soldering is removed with hot water. Vacuum baking and sealing also renders inert any flux that may remain.

Changes in effective resistance with tem-

THE AUTHOR: J. P. Griffin's entire career with the Laboratories has been closely associated with the design of filters and crystal units for filters and oscillators. After receiving a B.S. degree from Colorado A and M in 1930, he had continuous service with the Laboratories except for the years 1932-36 when he worked for the U. S. Geological Survey in the Bureau of Reclamation on a topographical survey party. At the Laboratories his first assignment was in the design of low frequency filters, equalizers, and phase correcting networks. During World War II he designed low frequency crystal units for filters and oscillators, and since then EDT synthetic crystals for carrier systems.

perature were thought to be at least partly dependent on the choice of solder for wire attachment, since the soldered joints are the only connection between the crystal element and the mounting assembly, and are also inseparably parts of the vibrating system. Since these connections control the degree of mechanical coupling between the two systems, the choice of solder should have a direct bearing on the dissipation of the vibrational energy. Sample crystals were made using various amounts of both 183 degree C and 231 degree C solder, but no significant electrical differences appeared. The 183-degree C eutectic was selected since it allows wire attachments at a relatively low temperature.

The cumulative effect of the improvements discussed above is a stability as high as 5 parts in 10^{10} per day and a Q as high as 4 x 10^{6}. These figures represent a ten fold improvement over any heretofore obtained in crystal units of this type.

During the past three years twenty of the new units have been supplied to the National Bureau of Standards and have been tested by Dr. W. D. George. Several of them are now being used as resonators to form a basic part of the primary frequency standards for station WWV in Washington. This station makes regular broadcasts of eight carrier frequencies ranging from 2.5 to 35 mc modulated with 440 and 4000 cycle per second tones, also one cycle per second pulses and time of day announcements.

David Sarnoff Gold Medal Awarded to A. G. Jensen

On October 8, at the annual banquet of the Society of Motion Picture and Television Engineers in Washington, A. G. Jensen, Director of Television Research of these Laboratories, was made a fellow of the Society and was awarded the David Sarnoff Gold Medal for 1952 "for his manifold contributions to the promulgating of monochrome and color television engineering standards, and for his work on the improvement of the quality of television pictures obtained from motion picture film."

Joining the Research Department in 1922, Mr. Jensen at first engaged in radio studies, and later took charge of developing terminal and measuring equipment for transmission over coaxial cable. Since 1938 he has been engaged in research work in television equipment and systems. In particular he has been responsible for the development of a high quality testing link which, employing motion picture film, can be used as a research tool for the evaluation of methods and systems for television transmission, and of the influence of component elements on the transmission quality. As a part of this he has been in charge of work on a succession of test film scanners, culminating in a development which was presented before the Society last year. He has also been responsible for research work on electrical, optical, and visual problems connected with television systems.

Mr. Jensen has taken part in many industry committees, particularly many committees, promulgating engineering standards for television as a result of their deliberations. He took an active part in the committee work of the first N.T.S.C. in 1941, from which came the engineering standards in monochrome television which are in use today. He continued to take an active part in the television activities of R.T.P.B. from 1944 to 1948, and of the panels of J.T.A.C. In the second N.T.S.C., established in 1950, he has been a member of several panels and is now vice-chairman of Panel 12 on Color System Analysis. He has been chairman of the I.R.E.-R.T.M.A.-S.M.P.T.E. Television Coordinating Committee in 1950-51; vice-chairman of the I.R.E. Standards Committee in 1949-50, and chairman in 1951-52; chairman of the I.R.E. Television Committee in 1948; and chairman of the I.R.E. Television Systems Committee in 1949-51. He was elected a Fellow of the I.R.E. in 1942, and has been Governor of the S.M.P.T.E. in 1952.

Transistors Enter Telephone Service

F. E. Blount at the left, designer of the oscillator, holds one of the oscillator units used in the frequency supply for multifrequency pulsing now in senders in the No. 5 crossbar office in Englewood, New Jersey. W. Shockley, at the right, is in charge of the group in which the transistor was invented.

Since their invention in Bell Laboratories several years ago, transistors* have been the subject of continuing research and development and have found a number of applications. In October of this year they were applied for the first time to commercial telephone service. In the No. 5 crossbar office in Englewood, New Jersey, they are now being used as a trial installation, in senders, to generate the six frequencies for the multifrequency pulsing† which is used for nation-wide dialing.

Heretofore the power supply for multifrequency pulsing has employed vacuum-tube oscillators assembled with associated equipment as a common unit. Two such units practically filled an entire bay. Each unit supplies a number of individual circuits, and to insure reliability, provisions were made to permit one unit to take over the load of both in case of failure.

With the availability of the transistor, it now becomes possible to make the six frequencies available in a unit small enough, and inexpensive enough, to be mounted as part of each sender. With such an arrangement, trouble in the frequency supply unit would effect only one sender, and the expense of transfer equipment to ship the load from one unit to another in case of failure is unnecessary.

Such a unit was developed by F. E. Blount of the Switching Systems Development Department and is shown herewith. The six transistors are the little button-like units projecting from the top of the case. For this installation in Englewood, the oscillator unit is used on a plug-in basis, which accounts for the two receptacles just evident at the upper end of the plate in the photograph. As is evident from the illustration, the frequency supply unit occupies the greater part of a 23-inch mounting plate. Before they are adopted for general use, however, it is expected that the unit will not require more than about half a plate.

* Record, *August*, 1940, *page* 321; *March*, 1949. *page* 89; *April*, 1949, *page* 129; *September*, 1950, *page* 400; and *August* 1951, *page* 379.

† Record, *December*, 1945, *page* 466.

An Automatic Dial Pulse Recorder

F. E. BLOUNT
Switching Systems Development

One of the interesting maintenance devices of the No. 5 crossbar system is the automatic monitor*, which as one of its functions records the dial pulses received by the originating register and also the information sent by the register to the marker as the result of these pulses. If these do not match, the trouble recorder† is called in and a full record of both is made. In the first No. 5 crossbar installation, it was found that a mismatch occurred in one out of about 500 calls. In less than five per cent of these mismatches, moreover, could any fault be discovered in the register that would account for them. It was obvious, therefore, that the great majority of the mismatches occurring were caused by unusual line conditions or dialing irregularities rather than by failure of any of the central office circuits.

The recording circuits in the register and monitor differ somewhat since the register responds to variations in line current which occur during dialing while the monitor responds to variations in voltage across the register pulsing relay and tone coil. The impedance of the monitor is very high, and thus the monitor has a negligible effect on the register pulsing circuit. Over the entire standard range of dial pulses and line conditions, the two circuits respond alike, but with badly distorted pulses there is always the possibility that their responses may differ somewhat. Under such conditions, the records in the monitor and register may not match. Since the mismatches that are not caused by a fault in the register, comprise the great majority of all mismatches, it seemed desirable to discover what was causing them. With this in view, a recording circuit was developed so that a record could be obtained of the pulses for all calls with which the monitor was associated.

Since there is no knowing when distorted pulsing will occur, it would be necessary to run the recording equipment continuously. During all but a very small fraction of this time, however, only normal pulsing would be recorded, and there would be no need for preserving the record. It was decided, therefore, to record on magnetic tape so that the record for normal periods could be erased, thus permitting a limited length of tape to be used over and over again. Circuits were developed, therefore, to permit the recorder to run continuously and, if no mismatches had occurred, to erase the record after about an hour's run and begin recording again on the same tape. When a mismatch was encountered by the monitor, however, an alarm would be given and the recorder stopped. The immediately preceding record, giving the pulses that caused the mismatch, could then be reproduced from the tape for a permanent record. After this, the recorder would again be put in operation.

The circuit developed for this purpose, and the method of associating it with the monitor, is shown in block schematic form in Figure 1. A standard commercial tape recorder was used for making the record, and since this operates only on ac, while the dial pulses are interrupted dc, it was necessary to convert the dc pulses received from the monitor to equivalent ac pulses before passing them on to the recorder. This was accomplished by allowing the dc pulses to magnetically modulate the 1,000 cycle output of an oscillator. The circuit employed is shown in Figure 2. Current from the oscillator is set at such a value that at

* Record, *August*, 1950, *page* 343.
† Record, *May*, 1950, *page* 214.

the peaks of the 1,000 cycle input the cores of the two transformers are saturated. As a result the ac wave at the output is rich in all the odd harmonics but displays practically no even harmonics. The secondary windings of the transformers are connected opposing, and thus, with only the ac input there is no output to the recorder. When

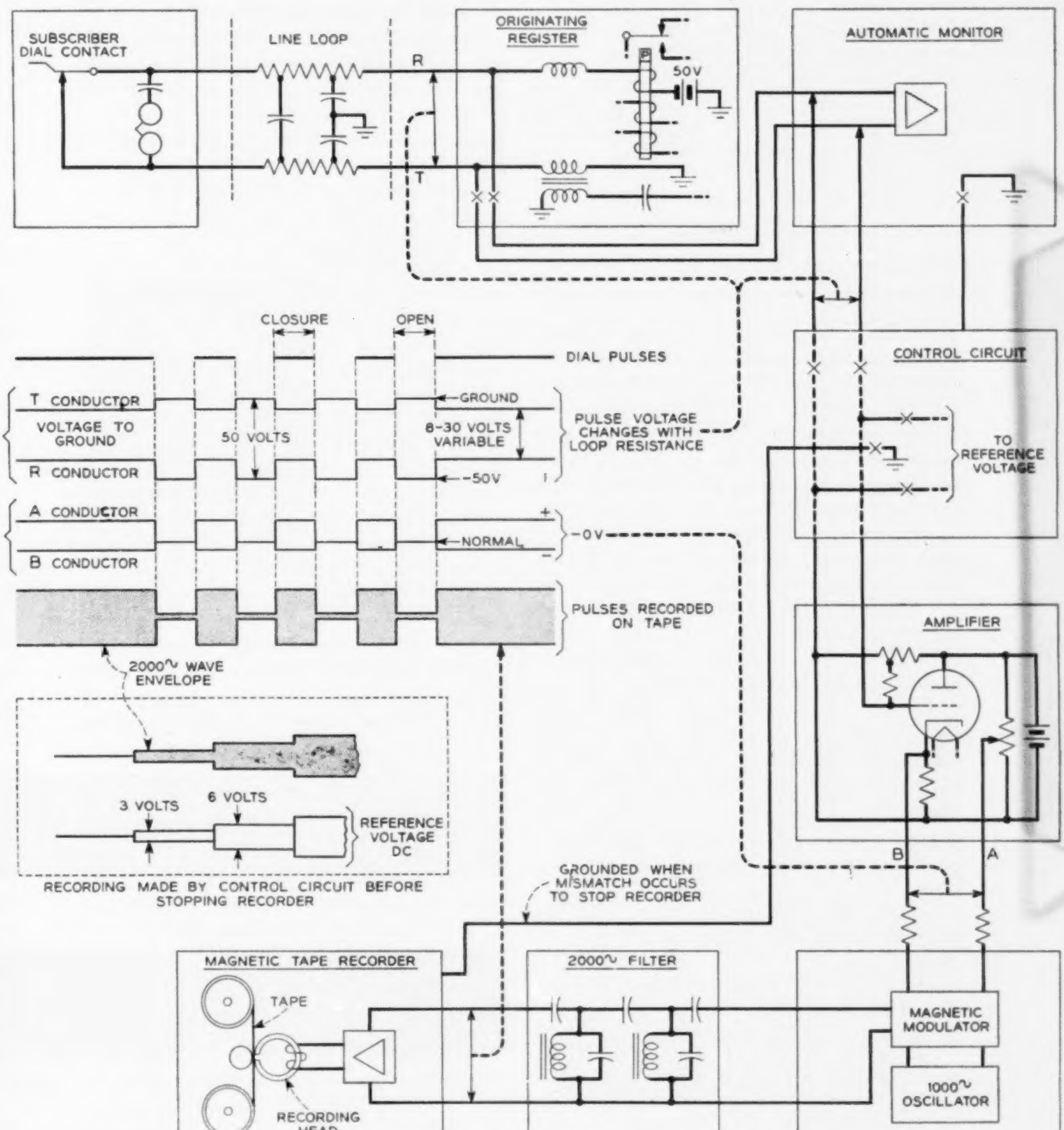


Fig. 1—Block diagram of dial pulse recording circuit.

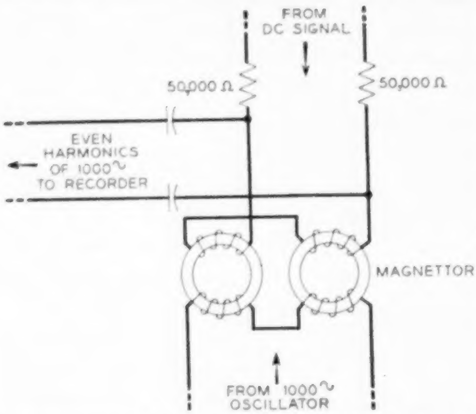


Fig. 2—Schematic of the magnetic modulator circuit.

dc flows in the secondary circuit through the connections indicated, however, the magnetic flux in the two transformers is slightly changed; the flux in one is decreased while that in the other is increased on each half cycle of the ac wave because of the opposing connections of the secondary windings. Because of this unbalance resulting from the flow of direct current, even harmonics of the ac are produced. Since even harmonics are not canceled by the reversal in the windings, there is a net output across the secondary terminals.

On its way to the recorder, this output is passed through a 2,000-cycle filter, and thus there will be a 2,000-cycle input to the recorder that varies with the direct current flowing in the line to which the monitor has been connected. When a subscriber is dialing over a normal circuit, the tape will record a 2,000-cycle wave except during those periods while the dial contacts are open.

Besides the recorder, the filter, and the magnetic modulator (magnettor), the recording circuit includes an ungrounded amplifier of the cathode follower type, placed in the path of the pulsing signals between the monitor and the magnetic modulator. Its principal function is to prevent the ac of the modulating circuit from reaching the subscriber line.

When the monitor encounters a mismatch, it grounds a lead to the control circuit of the recorder. In response to this ground, the control circuit at once opens the circuit to the monitor, and then applies a succession of three fixed voltages to the recorder circuit to cause a calibration pattern to be recorded on the tape. After this, the recorder is stopped and an alarm is sounded. A twenty-foot section of tape on which the pulses were recorded is then cut out and tagged for study at a later date, and the recorder tape is patched together so that the test may be resumed. A voice record is then made on the section of the tape that has been removed of the date the mismatch occurred and the number of the associated trouble record. To obtain a record for visual inspection, the output of the tape recorder used for playing back the record is connected to a string oscillograph and a record is made of the output signal.

As indicated in Figure 1, the tape recorder has two reels, and holds about 1,200 feet of tape. A record may be made with the tape running in either direction. The effective length of the recording is about double the length of the tape since the recording covers only half its width. A record is made on one-half of the tape for its full length and then the machine is automatically reversed and a recording is made on the other half while the tape is running in the other direction. At the completion of this second half, the machine is stopped and an alarm is sounded. The machine is then set to erase the previous record just in advance of the recording

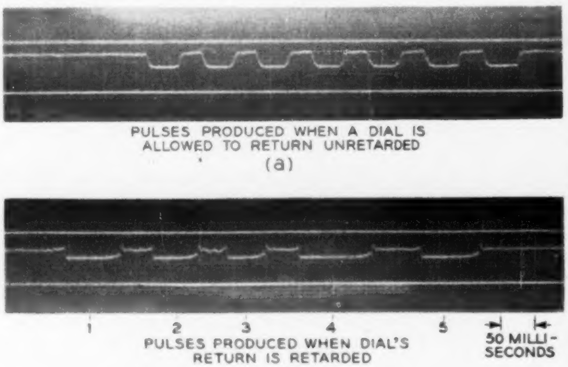
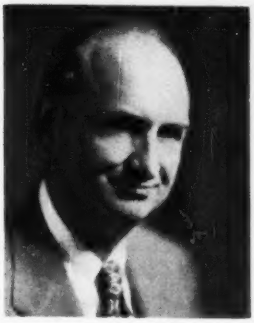


Fig. 3—Pulses produced when a dial is allowed to return unretarded, above, and when the dial is retarded, below.

head, and a new cycle is started. The tape speed is about 7½ inches per second, and thus the twenty-four hundred feet of record requires just about one hour for its making.

A record of pulsing that caused a mismatch is shown in Figure 3 as it appears after the tape recording has been demodulated and played back to a string oscillograph. In this particular instance, the dial had apparently been slowed down, perhaps by failure to remove the finger during the return of the dial. This resulted in pulses with a ratio of make to break much beyond the allowable limit. Thus the responses of the register and monitor were enough different to cause different numbers to be recorded. Other mismatches were found to be due to switchhook flashing, to excess line leakage current, and to power-line interference on unbalanced two-party lines.

The recording circuit described above has proved very valuable in studies of this type. It was installed in a central office and was in continuous use while these studies were being made. Since then it has been brought back to the Laboratories and is being held for possible use in the future.



THE AUTHOR: Frank E. Blount joined the Laboratories in 1928, after he was graduated from Oregon State College with a B.S. degree in E.E. After testing panel switching systems circuits for a year, Mr. Blount joined a group developing signaling circuits and special circuits for use in switching systems. He continued in this work until 1940, when he worked on automatic ticketing for the step-by-step system. During World War II, he helped develop test equipment for radars, and since then has been designing circuits for the No. 5 crossbar system.

Radio-Relay Route Planned for Middle West

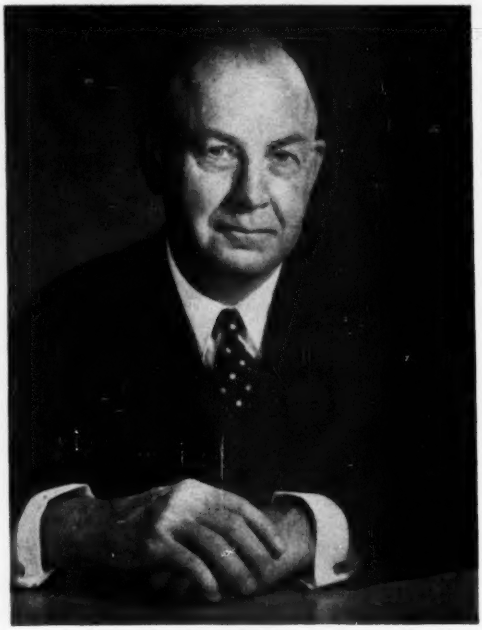
A microwave radio-relay system, connecting Minneapolis with Milwaukee and Chicago to provide needed telephone facilities, has been outlined in a construction application filed with the Federal Communications Commission, by the A T & T Long Lines Department. Scheduled for completion by the middle of next year, the $5 million project will initially provide 500 telephone circuits.

Augmenting cable and wire facilities now providing communications in this area, the new 423-mile skyway will tie in with the coast-to-coast microwave and toll cable routes at Chicago. It will provide four broadband channels to Minneapolis for telephone use. In addition, two channels for telephone and one for television will be installed between Chicago and Milwaukee. The television channel will replace provisional radio-relay facilities now furnishing TV network service to Milwaukee.

The new communications highway will travel 88 miles northwest of Chicago to a radio-relay station at Palmyra, Wis., where it will split with one branch going to Milwaukee and the other to Minneapolis. To relay calls along the system, twelve intermediate microwave stations will be required with antenna towers varying in height from about 135 to over 300 feet.

Future plans call for TV channels from Chicago to Minneapolis to provide another route to Minneapolis now connected to the Long Lines TV network by coaxial cable out of Des Moines, Ia.

C. F. Craig Honored



Cleo F. Craig

The American Society for Metals, at its annual banquet, presented to Cleo F. Craig, President of American Telephone and Telegraph Company, its 1952 "Medal for the Advancement of Research." This is the tenth impression of the medal.

Recipients of the nine previous awards were: Roy A. Hunt, Aluminum Company of America; Robert C. Stanley, International Nickel Company; Gerard Swope, General Electric Company; R. E. Zimmerman, U. S. Steel Corporation; Charles R. Hook, American Rolling Mills; Willard H. Dow, Dow Chemical Company; Fred H. Haggerson, Union Carbide & Carbon Company; Charles E. Wilson, General Motors Company; and, Gwilym A. Price, Westinghouse Electric Manufacturing Company.

Mr. Craig was cited for his "keen interest in the improvement and extension of communication through research." It was particularly noted that "as a member of the Board of Directors of Bell Telephone Laboratories and subsequently as President of American Telephone and Telegraph Company, Mr. Craig has supported and promoted metallurgical research by giving his active encouragement and approval to the Laboratories' program."

The medal is awarded by the Society to an executive in an industrial organization who, over a period of years, has consistently sponsored metallurgical research or development and who, by his foresight and his influence in making available financial support, has helped substantially to advance the art and sciences relating to metals.

Joint A. I. E. E.–I. R. E. Course

Transistor Circuitry is the title of a joint A. I. E. E. – I. R. E. lecture course being given by the New York Sections of the two societies this fall. The opening lecture on October 20 was given by R. L. Wallace on the subject of *Transistor Operating Characteristics*. The remaining lectures are as follows: October 27, *Linear Amplifiers*, by Dr. Harwick Johnston, RCA Laboratories; November 3, *Linear Negative Impedance Circuits*, by J. G. Linvill, Bell Laboratories; November 10, *Oscillators and Power Amplifiers*, by J. S. Schaffner, General Electric Company; November 17, *Pulse Techniques –Astable and Monostable Circuits*, by J. R. Harris and L. W. Hussey, Bell Laboratories; and November 24, *Pulse Techniques–Bistable Circuits*, by R. L. Trent, Bell Laboratories.

I. R. E. Fellow Awards for 1953

Among the forty-nine radio engineers and scientists named Fellows of the I. R. E. by the Board of Directors at its meeting September 10, are four Laboratories scientists – E. B. Ferrell, J. A. Morton, S. O. Rice, and A. A. Roetken. The award of Fellow, highest membership grade of the I. R. E., is bestowed upon those who have made outstanding contributions to radio engineering or allied fields. Presentation of the awards with citations will be made by the President of the Institute at the annual banquet March 25, 1953, during the 1953 National Convention.

A. I. E. E. Representation at the Laboratories

During the fiscal year 1952-53 of the A.I.E.E., a number of Laboratories' people are active in the various general and technical committees. D. A. Quarles, formerly Vice President of Bell Telephone Laboratories and now President of Sandia Corporation, is President of the Institute. He is also Chairman of the Executive Committee, and A.I.E.E. Representative on the Conference of Representatives from Engineering Societies of Western Europe and the United States.

Board of Examiners, R. A. Heising, E. C. Molina (retired), F. J. Scudder (retired), and H. M. Trueblood (retired). *Edison Medal Committee,* R. I. Wilkinson and O. B. Blackwell (retired). *Membership Committee,* Charles Clos, Chairman. *Committee on Transfers,* Charles Clos, Vice Chairman. *Committee on Planning* and *Coordination,* E. I. Green. *Committee on Award of Institute Prizes,* E. I. Green, Chairman, and L. G. Abraham. *Committee on Technical Operations,* J. D. Tebo, Vice Chairman, and E. I. Green. *Science and Electronics Division Committee,* E. I. Green, R. M. Bozorth, and W. H. MacWilliams, Jr. *Publication Committee,* J. D. Tebo. *Sections Committee,* J. D. Tebo. *Committee on Public Relations,* R. K. Honaman. *Safety Committee,* L. S. Inskip. *Standards Committee,* R. D. de Kay*. *Communication Division Committee,* H. A. Affel, Vice Chairman, L. G. Abraham, A. C. Dickieson, P. G. Edwards, and J. Meszar,

Committee on Radio Communication Systems, A. C. Dickieson, Chairman. *Committee on Communication Switching Systems,* J. Meszar, Chairman, W. Keister, Secretary, and R. C. Davis. *Committee on Wire Communication Systems,* P. G. Edwards, Chairman, L. R. Montfort, Secretary, and L. G. Abraham. *Committee on Telegraph Systems,* R. B. Shanck, Secretary, and E. F. Watson.

* Assigned to the Communication and Electronics Division of the Electrical Standards Committee of A.S.A. and the U. S. National Committee of the International Electrotechnical Commission.

Committee on Television and Aural Broadcasting Systems, J. W. Rieke. *Committee on Feedback Control Systems,* J. G. Ferguson. *Committee on Instruments and Measurements,* E. P. Felch and J. G. Ferguson. *Committee on Metallic Rectifiers,* D. E. Trucksess. *Committee on Electronics,* D. E. Trucksess. *Committee on Magnetic Amplifiers,* A. B. Haines. *Committee on Basic Sciences,* R. M. Bozorth, Chairman, V. E. Legg, Secretary, and J. D. Tebo. *Committee on Computing Devices,* W. H. MacWilliams, Jr., Chairman. *Committee on Protective Devices,* P. A. Jeanne. *Committee on Transmission and Distribution,* P. A. Jeanne.

New York Section of A. I. E. E. Elect Officers

Officers for the New York Section, A. I. E. E., for the year 1952 include the following Bell Laboratories members: Communication Division—W. T. Rea, Chairman, M. A. Townsend, Secretary-Treasurer and A. E. Joel, Chairman Educational Committee. The Advisory Committee, made up of the five most recent Past Chairmen of the Section, includes J. D. Tebo.

National Electronics Conference Holds Meeting in Chicago

Several Laboratories engineers presented papers at the Eighth Annual National Electronics Conference and Exhibition held in Chicago from September 29 to October 1. In the session on *Equipment and Components Reliability,* O. C. Eliason presented a paper on *Component Unreliability in Military Equipment.* The *Transistors* session included the paper by K. D. Smith, *Properties of Junction Transistors,* and one by R. L. Trent, *A Transistor Reversible Binary Counter.* In the session *Coding and Recording Techniques,* J. N. Shive presented a paper by H. G. Follingstad, R. E. Yaeger and himself on *An Optical Position Encoder and Data Recorder.* The session on *Delay Lines and H. F. Test Equipment* included E. S. Pennell's paper entitled, *Vitreous Silica for Ultrasonic Delay Line Applications.*

Frank Gray Honored by I. R. E.

Frank Gray has been awarded the Vladimir K. Zworykin Television Prize Award for 1953, given annually by the I. R. E. for an outstanding contribution to television. A pioneer in the television field, Mr. Gray, early in the 1930's, developed principles, the importance of which has only recently been recognized and which are embodied in the color television system currently under development by the industry-sponsored National Television System Committee. That he holds an expired patent concerned with these principles indicates the pioneering character of his work in this field. Mr. Gray retired Oct. 1, 1952.

Radio Relay Activities

A TD-2 radio relay system over a second route between New York and Washington has been placed in service by the Long Lines Department. The new route, which will initially provide two southbound television channels, is via Philadelphia and Baltimore.

TD-2 equipment has now replaced all but the last section of the TE equipment on the radio relay system between Portland and Seattle which was rushed into service in time for the political conventions.

National Bureau of Standards' Board of Visitors

M. J. Kelly, president of Bell Telephone Laboratories, has been named a member of the Board of Visitors of the National Bureau of Standards. The Board of Visitors is an advisory body provided for in the basic law establishing the Bureau and is appointed by the Secretary of Commerce. The term of appointment is for five years with a new appointment made each year.

J. B. Fisk Appointed to A. E. C. Advisory Committee

J. B. Fisk was one of the three new members appointed to the General Advisory Committee to the Atomic Energy Commission, by President Truman. The other members appointed were Dr. Eugene P. Wigner of Princeton and Dr. John C. Warner, President of Carnegie Institute of Technology. Appointments are for six-year terms. The new members replace three other scientists whose six-year terms expired—Dr. James B. Conant, President of Harvard University, Dr. Lee A. Dubridge, President of California Institute of Technology, and Dr. J. R. Oppenheimer, Director of the Institute for Advanced Study at Princeton.

Overseas Service to Lebanon

Radio telephone service to Lebanon on the eastern seaboard of the Mediterranean, was inaugurated September 1 by Long Lines. Overseas operators in New York began placing calls to the distant republic via Paris, France, after negotiations were completed with the telephone officials of the Lebanese and French Administrations. The rate (excluding tax) for a three-minute call between Lebanon and any point in the United States is $15.

Mobile Telephone Service in Canada

Installation of twenty-five mobile radio stations operating in the 152-162 mc range is being undertaken by the Bell Telephone Company of Canada. These stations are to be located in Ontario and when all are completed, will provide wide coverage of the main highways between Toronto and Windsor. Base stations of the New York Company at Buffalo and of the Michigan Company at Detroit will provide coverage in adjacent areas in Canada. Discussions are under way between Bell of Canada, New York and Michigan companies looking to the settlement of various matters relating to the use of the Buffalo and De-

troit base stations for this chain. The network of stations will be used to serve the Province of Ontario highway operation and maintenance vehicles as well as furnishing service to the public.

Mobile service is now available through Bell of Canada stations in Montreal, Toronto and Barrie. Six channels are in service which serve 271 mobile telephones. Two of these channels, one each at Toronto and Barrie, are in the 30-44 mc band and will be retired eventually, the present plan being to provide all service by the use of 152-162 mc frequencies.

Patents Issued to Members of Bell Telephone Laboratories During the Month of August

2,606,309 – *Glow Discharge Device* – M. A. Townsend.

2,606,314 – *Regulated Rectifier* – J. A. Potter.

2,606,405 – *Polishing Means and Method* – R. S. Ohl.

2,606,443 – *Exploration of Troposphere Stratification* – G. W. Gilman.

2,606,817 – *Preparation of Microphonic Carbon* – C. E. Mitchell.

2,606,960 – *Semiconductor Translating Device* – J. B. Little.

2,606,961 – *Carrier Telegraph Repeater* –L. C. Roberts.

2,607,010 – *Wave Guide Antenna System* – W. E. Kock.

2,607,015 – *Multicathode Glow Discharge Device* – M. A. Townsend.

2,607,021 – *Gas Filled Discharge Device* – H. L. von Gugelberg.

2,607,030 – *Current Regulation* – L. A. Meacham.

2,607,092 – *Clamp for Cylindrical Objects* – H. C. Rubly.

2,607,216 – *Torsional Interferometer* – W. P. Mason.

2,607,219 – *Torque Measuring Tool* – A. C. Millard and O. C. Morrill.

2,607,272 – *Composite Wave Plate for Light* – W. L. Bond.

2,607,281 – *Ventilating Fixture for Telephone* – D. H. King.

2,607,843 – *Remote Control and Supervisory System* – R. B. Hearn and H. M. Pruden.

2,607,850 – *Wave Guide Impedance Element* – A. G. Fox.

2,607,851 – *Mop-Up Equalizer* – K. W. Pfleger.

2,607,852 – *Telegraph Repeater* – W. T. Rea.

2,607,858 – *Electromechanical Transducer* – W. P. Mason.

2,607,859 – *Telephone Transmitter* – H. W. Bryant.

2,607,887 – *Radio Telephone System* – F. E. Gissler and J. F. Laidig.

2,607,891 – *Translating Circuits Utilizing Glow Discharge Devices* – M. A. Townsend.

2,607,892 – *Timing Circuit* – G. H. Marmont and B. M. Oliver.

2,607,901 – *Electronic Discharge Device* – G. H. Rockwood, Jr. and R. L. Vance.

2,607,902 – *Gaseous Discharge Device* – M. A. Townsend.

2,607,916 – *Light Controlled Channel Deviation Indicator* – W. J. Albersheim.

2,608,265 – *Ribbon-Type Microphone Diaphragm* – H. Eckardt.

2,608,597 – *Cage Assembly for Crystals* – A. W. Ziegler.

2,608,601 – *Capacitor* – E. M. Boardman.

2,608,610 – *Transformer* – C. W. Thulin.

2,608,611 – *Selenium Rectifier Including Tellurium and Method of Making it* – J. N. Shive.

2,608,616 – *Facsimile Systems* – K. W. Pfleger.

2,608,617 – *Television Converter System* – H. A. Affel and J. B. Maggio.

2,608,619 – *Telegraph Hub Repeater* – J. R. Davey and W. T. Rea.

2,608,621 – *Magnetic Record Detector* – E. Peterson.

2,608,623 – *Wave Transmission Amplifier* – C. C. Cutler and W. E. Mathews.

2,608,630 – *Relay* – H. C. Harrison.

2,608,668 – *Magnetically Focused Electron Gun* – M. E. Hines.

2,608,674 – *Multicathode Glow Discharge Device* – W. A. Depp.

2,608,681 – *Voltage Regulation* – B. E. Stevens.

President Kelly Addresses Industrial Designers

Dr. Kelly was the principal speaker at the banquet opening the 7th Annual Convention of the Society of Industrial Designers, held beginning October 3 at Shawnee-on-Delaware. Speaking on *The Industrial Designer—His Place and Contribution in Our Society*, Dr. Kelly pointed out that the work of the scientist and engineer had greatly increased the production of wealth, had lessened men's physical labor, and had brought increased comforts and luxuries for his enjoyment. This increasing emphasis on our material side of life has undoubtedly been accompanied by some decrease in emphasis on the aesthetic side. It is the function of industrial designers to assist in restoring the balance. In closing his talk Dr. Kelly said: "Industry needs you – all industry needs you – and as your value and the ways of working with you are more universally appreciated your number will grow and your contribution increase."

THE BOARD OF TRUSTEES of Princeton University has elected M. J. Kelly to membership on the Advisory Council of the Department of Electrical Engineering for the three-year term beginning July 1, 1952.

THE ETA KAPPA NU Association has invited Dr. Kelly to serve on the Jury of Award to select the most outstanding young electrical engineer for the year 1952.

R. K. HONAMAN addressed a conference of the American Management Association on October 1, 1952, in the Hotel Astor. He spoke on *The Right Point of View in Employee Information*. The conference inaugurated a series of twelve national meetings to be held throughout the nation during the coming year. At this first session industrial relations executives and other representatives of management from all parts of the United States were present.

G. E. PETERSON and G. RAISBECK are in Europe to attend a Symposium on *Applications of Communication Theory* held at the Imperial College of Science and Technology in London. Mr. Peterson will present a paper, of which he is the author, entitled *Information Bearing Elements of Speech*. Mr. Raisbeck will present a paper, co-authored by K. H. Davis, R. Biddulph, and S. Balashek, entitled *Automatic Recognition of Spoken Words*. Later Mr. Peterson will journey to San Remo to present his paper before the Audio Technical Congress.

A PAPER entitled *Vitality of a Research Institution and How to Maintain It* was read before the Atlanta Research Management Conference last month by R. BOWN, Vice-President of the Laboratories.

A NUMBER of Laboratories people attended a Conference on Gaseous Electronics held at the RCA Research Center in Princeton, N. J. These included K. G. McKAY, H. D. HAGSTRUM, G. H. WANNIER, R. N. VARNEY, D. J. ROSE and C. HERRING. Papers were read by Messrs. Hagstrum, Wannier, Varney and Rose.

F. R. BIES was at Settlement Point on Grand Bahama Island July 26 to August 3 as an observer on measurements of transmission and impedance and cross-talk on the submarine cable system for the United States Air Force Missile Testing Center.

J. R. ANDERSON, B. D. HOLBROOK, W. D. LEWIS, and E. F. MOORE attended the meeting of the Association for Computing Machinery at the Computation Center, University of Toronto. Mr. Anderson presented a paper on *Ferroelectric Materials as Storage Elements for Digital Computers and Switching Systems*. Mr. Moore spoke on *A Simplified Universal Turing Machine*.

W. D. LEWIS has been appointed by the Board of Overseers of Harvard College to serve on the Committee to Visit the Division of Applied Science of Harvard University during the academic year 1952-53.

ON FRIDAY, October 10, approximately 250 members of the Laboratories who have participated over the past year and a half in a large guided missile project* assembled at Whippany to inspect models of this equipment about to be shipped to the White Sands Proving Ground for test. Movies were shown of the activities on the project over the past two years.

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